

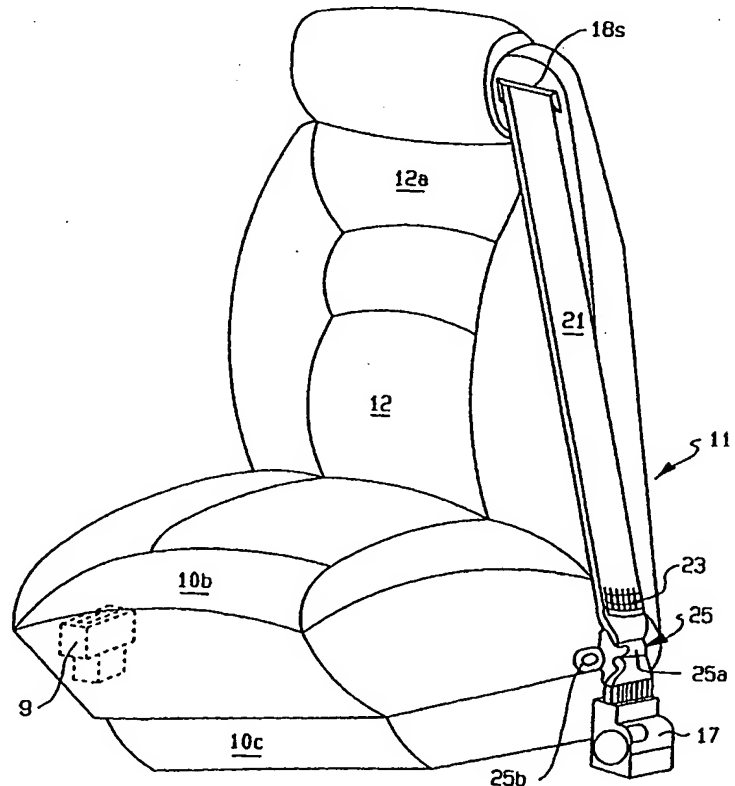
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

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(54) Title: BELT SYSTEM WITH INFLATABLE SECTION WITHIN AN OUTER BELT SECTION AND METHOD OF RESTRAINT

## (57) Abstract

An inflatable belt system and method of operation for vehicle occupant restraint in which a lap belt section or torso belt section or both have dual load bearing portions with an inner portion being inflatable. During inflation of the inner portion the other outer belt portion ruptures along a selected weakened line or area.



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BELT SYSTEM WITH INFLATABLE SECTION WITHIN  
AN OUTER BELT SECTION AND METHOD OF RESTRAINT

Background of Invention

5 Inflatable seat belts have included perforated fabrics  
(U.S. Patent No. 3,801,156)). Other belts have included  
folded woven fabric bodies within a rupturable cover (U.S.  
Patent No. 5,346,250). Inflatable belts have been pleated  
and stitched for use prior to inflation reinforcing material  
10 (U.S. Patent No. 3,866,940).

Prior inflatable seat belts have included decorative  
covers which had little or no load bearing ability. Further,  
the attachment between the inflatable sections and the non-  
15 inflatable sections in prior belts lacked sufficient  
reinforcement to withstand the high loading occurring during  
a crash.

Summary of the Invention

20 Broadly, the present invention comprises a vehicle seat  
and seat belt system including (1) a tubular webbing made of  
fabric or other suitable material having strength  
characteristics, not unlike a conventional seat belting, and  
(2) having an inflatable tube, bladder or other inflatable  
25 component positioned in the tubular webbing. The outer  
tubular webbing component is longitudinally frangible to  
allow the inner inflatable component, as it is inflates, to  
exit through a rupture opening in the tubular webbing during  
the period of vehicle deceleration pending a crash. The  
30 pressure and forces of the inflation of the inner component  
cause the outer tubular webbing to rupture. The combination  
of outer tubular webbing and inner inflatable component may  
be used in a torso section, a lap section or both.

35 The belt system may be used in combination with a  
structural seat having a frame in which a belt enclosure and  
anchor are positioned behind the occupant and secured to the

seat frame. The enclosure houses the torso section of the belt system which torso section includes the outer and inner belt components. An inflator may be positioned within the inner inflatable components. The amount of belting withdrawn 5 from the enclosure depends on the size of the occupant as he or she buckles up.

Alternatively, the belt enclosure and anchor may be mounted on other portions of the vehicle including its frame.

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Brief Description of the Drawings

Fig. 1 is a perspective view of the vehicle seat with a belt system of the present invention;

15 Fig. 2 is the same view of Fig. 1 in which the belt system is being buckled up around and without the occupant being shown;

Fig. 3 is a rear perspective view of the seat frame, 20 rear belt enclosure and anchor mounted to the seat;

Fig. 4 is a broken-away perspective view of that portion of the belt including an inflator which portion resides in the belt enclosure;

25

Fig. 4a is a sectional view taken along line 4a-4a of Fig. 4;

Fig. 4b is a sectional view taken along line 4b-4b of 30 Fig. 2;

Fig. 5 is a perspective view of the seat of Fig. 1 with the torso section of the belt system inflated;

Fig. 6 is a side sectional elevation view of the torso 35 belt section inflated;

Fig. 6a is a sectional view through line 6a-6a of Fig. 6;

Fig. 6b is a sectional view along line 6b-6b of Fig. 6;

Fig. 6c is a sectional view similar to Fig. 6b after inflation and the load of the occupant's torso applied against the inflated belt component;

Fig. 7 is a side sectional view of the torso belt portion prior to activation of the inflator;

Fig. 8 is an enlarged view of the torso belt with a tubular outer belt expanded by inflation of the inner component as supplied with gas;

Fig. 9 is a perspective view of a portion of the fabric of the outer tubular belt component;

Fig. 10 is a plan view of the portion and the fabric of the outer tubular belt component;

Fig. 11 is a plan view of a portion of the alternative fabric of the outer belt component;

Fig. 12 is a perspective view of the alternative fabric; and

Fig. 13 is a perspective view of another embodiment of the present invention in which the belt enclosure is mounted adjacent the seat on the vehicle frame.

#### Detailed Description of the Invention

With respect to Figs. 1-3, vehicle structural seat includes a belt system 11 in turn comprising occupant restraint belt 13 including torso section 21 and lap section 22. Torso section 21 has, in its unbuckled mode, two (2)

ends with one end connected to back take-up retractor anchor reel 16 positioned behind a seated occupant (Fig. 3) and the other end connected to a side anchored buckle 9 (Fig. 1).

Torso belt section 21 reciprocally moves in belt guide

5 enclosure 18 as the length of belt component 19 pays out and back into retractor anchor 16. Belt enclosure 18 and anchor 16 are secured to seat frame 24.

Torso belt section 21 includes tandemly connected rear  
10 belt portion 19 (which changes direction as it passes around guide ring 15). Torso belt section 21 extends from belt stitching 23 adjacent seat side reel anchor 17 upwardly alongside the occupant's torso into enclosure slot 18s and includes belt portion 19 attached by stitching 14. Belt  
15 portion 19 is preferably made of conventional belt webbing. Inflator 20 is held within belt section 21 and moves along with torso belt portion 21 as it reciprocates. The position of inflator 20 in the buckled up mode therefore depends on the amount of belt component 21 utilized by the occupant as  
20 he or she buckles up which amount varies with the occupant's size and shape.

Lap belt section 22 has a tongue connector 25 with belt holding opening 25a and tongue 25b. Vehicle seat 10 also  
25 includes seat portion 10a, back portion 12 with upper back portion 12a, base portion 10c and frame 26 (Fig. 3). A structural seat including enclosure belt guides is described in pending U.S. Application Serial No. 08/815,658 filed March 13, 1997 entitled "Inflatable Passenger-Size Adjustable Torso  
30 Belt System Including Enclosure Mount and Method of Passenger Restraint", which application is incorporated here by reference. Also shown is guide enclosure 18, upper enclosure slot opening 18s and gas-creating and discharging inflator 20.

35

Turning now to Figs. 4-6, torso belt section 21 includes an outer tubular belt component 32 and an inner belt

component 31 which inner component 31 is folded for storage within outer component 32. Inner inflatable component 31, when inflated, has a diameter to width of outer belt component 32 ratio in the range of three (3) to four (4) 5 which range may be as high as five (5) or six (6). Component 31 as stored includes folds 31a-31h (Figs. 4, 4a and 4b). Fig. 4a shows a belt cross section within enclosure 18 while Fig. 4b shows a cross section of the belt section 21 across the occupant's torso. Belt component 32 has tits 32t 10 on either side. Frangible line (fiber) 36l lies in one of tits 36t. Torso belt inflation should be large enough in diameter and length to push the occupant back in his or her seat but not large enough to press occupant against the seat to the extent injury would occur due to such torso belt 15 inflation. As a crash event loads torso belt section 21, the load is shared by both (1) the outer tubular component 32 and (2) the inner inflated (partially or completely) component 31. Partial inflation occurs within enclosure 18 due to the restraint enclosure 18 provides.

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In the first and earliest phase of a crash, inflator 20 is caused to supply gases to inner component 31 which starts to inflate exerting pressure on the inner walls of outer component 32. When the pressure reaches a certain level the 25 outer component 32 ruptures along frangible line 36l and the inner belt portion 31 starts to exit through the ruptured area 36 (Fig. 5). Frangible line 36l is preferably along an edge of inner component 32 (Fig. 4a). The rupturing of outer belt component 32 substantially reduces its ability to 30 withstand loads without substantial elongation.

As vehicle and occupant deceleration continues, outer belt component 32 begins to stretch due to forces created by the occupant while at the same time the inner belt component 35 31 begins to pretension and foreshorten as it takes up a portion of the load. In the next phase when the inflating component 31 has deployed further, inner belt component 31

takes more load and the outer belt component 32 carries less load. Finally, when the inner component 31 is fully deployed, the inner component 31 assumes substantially all the load (from 60%-90%). Since outer and inner components 5 share the crash load, each can be made thinner, lighter and of lower strength than a conventional vehicle restraint belting. Components 31, 32 may be made of any suitable material. The preferred material is woven fabric such from polyester or nylon fibers or threads. The outer tubular 10 section 32 has a strength of 3,000 to 6,700 lbs. and an elongation of less than 10% at 2,500 lbs. Frangible warp fiber 37 has a low denier of 50 to 420.

Full inflation of torso belt 21 occurs between stitching 15 23 (Fig. 5) and stitching 14 (Fig. 3) with inflation of the inner component 31 and its deployment outside outer component 32 occurring between stitching 23 and enclosure exit 18s (Fig. 5).

20 Figs. 6, 6a, 6b and 6c show the outer belt webbing component 32 deployed through slot 36 formed by the rupture of outer belt component 32. Limited inflation occurs within belt enclosure 18 utilizing some of the gases discharged by inflator 20 but the great majority of gases provided by 25 inflator 20 inflate the portion of inner component 31 shown in Figs. 5 and 6 for torso restraint.

In Fig. 6c, the operation of deployed inner inflated component 31 after outer component 32 has stretched due to 30 its weakened condition includes component 31 coming into contract with occupant's torso (T) to arrest forward torso movement. The shape of inflated component 31 is changed from circular to oval shaped by the forces required to arrest the occupant's torso (T).

35

Fig. 7 illustrates the location of inflator 20 within torso belt 21 prior to inflation and Fig. 8 shows the torso

belt 21 inflated within the restraints of the inner walls 18w of enclosure 18.

Fig. 9 shows a woven fabric portion 30 of tubular belt section 32 with longitudinal fiber or thread 37 which fails due to tension in cross or fill fibers 35. Fig. 10 in an enlarged view illustrating fabric portion 30. Inflation causes cross fill fibers 35 to pull on frangible thread 37 to cause it to rupture creating longitudinal opening 36.

10

In Figs. 11 and 12 an alternative arrangement for providing pressure induced rupture of the tubular webbing component 32 is shown in which fiber 39 is preweakened by chemical etch or laser light. Of course, fibers can be weakened by reduction of fiber cross-section. Alternatively, the webbing may be weakened by a hot knife or wire or by water jet. Seam 39 is broken by the pulling of fill fibers 41.

20 Turning to Fig. 13, an alternative embodiment is shown in which belt 13' passes into a belt enclosure 40 positioned adjacent seat 10'. Enclosure 40 is attached to vehicle frame pillar 44. Enclosure 40 includes an upper slot opening 40s and a belt take-up anchor 42. Also shown are seat 10', seat 25 back 12' and side take-up reel 17'.

In operation of restraint belt 13 including its torso section 21, an occupant sits in seat 10 and he or she pulls tongue connector 25 having tongue 25b over his or her lap and 30 inserts tongue 25b in lap right side buckle receiver 14 (Fig. 1). As this buckling up step is carried out, torso belt section 21 including its hidden rear web portion 19 pays out of retractor anchor 16. At the same time lap belt section 22 pays out of anchor 17. The amount of belt pay out depends on 35 the occupant, with more belt being payed out for a larger occupant than a smaller occupant. Inflatable torso section 21 which pays off anchor 16 exits guide enclosure slot 18s,

in upper seat back 12a (Fig. 2). Belt system 13 is designed so that inflator 20 and a length of attached belt 19 remain in the belt guide enclosure 18, even when the largest occupant is being accommodated.

5

In further operation of the system during a crash event when the vehicle experiences rapid deceleration, a crash sensor (not shown) activates inflator 20 which discharges gases into inner belt component 31. Anchors 16, 17 lock up  
10 preventing any additional belt pay out. Since inflator 20 is located in enclosure 18 behind seat 10 or adjacent the seat in enclosure 40, the gases first discharged from inflator 20 expand inner component 31 to the extent it can expand within the confines of enclosure 18. Since enclosure 18 restrains  
15 belt section expansion, inner section 31 does not emerge from outer belt section 32 even if section 32 develops a frangible split due to internal gas pressures.

Once belt section 21 in enclosure 18 has been inflated  
20 to the extent permissible, further discharged gases serve to inflate the torso belt section 21 outside enclosure 18 and adjacent the occupant's torso. When pressure in the torso belt 21 outside enclosure 18 reaches a certain level, frangible fibers in outer belt component 32 break causing  
25 component 32 to rupture at a point and then rapidly along the longitudinal length of the belt component 32 between slots 18s and stitching 23 (Fig. 5) creating rupture opening 36. Fiber 37 varies in strength along its length with its weaker portion being at the lower torso end adjacent stitching 23  
30 remote from the area of occupant's head and slot 18s. Such variation in fiber strength causes emergence of the inner belt component 31 at the area just above stitching 23 prior to its emergence at the area adjacent the occupant's head.

35 During vehicle deceleration and phases of inflation of torso belt section 21 the system functions to decelerate the occupant as follows:

1. Outer belt component 32 being in engagement with the occupant's torso resists occupant's forward motion. The area (width times length) of outer belt 32 (which is initially loaded by occupant's movement) is an area  
5 equal to or substantially equal to the area of the outer belt 32 prior to any inflation. Such area in contact with the torso is in the range of 50 to 68 in<sup>2</sup>.

2. Upon the onset of inflation of the inner torso component 31 and the rupture of outer belt component 32, outer component 32 is reduced in strength due to the rupture-created slot 36 (Figs. 5 and 6). As the occupant is decelerated component 32 elongates and  
10 narrows.

3. As outer belt component 32 elongates and narrows, inner inflated component 31 is expanding laterally as it is inflated causing it to shorten. Further component 31 as it shortens is subjected to the  
15 load exerted by the occupant which load becomes greater than the load on the outer section.

4. By the time inner belt section 31 is fully inflated and occupant deceleration is reaching a point  
25 where a maximum load is being placed on belt system 11, the inner component 31 serves as the principal occupant restraint. Inner belt component 31, also made of fabric or similar material, stretches as it is loaded providing in its inflated state, a cushioning effect against  
30 occupant's torso. Upon full inflation, the area of belt contact with the torso is in the range of 150-180 in<sup>2</sup> depending on the width of tubular webbing 31 and the size of the occupant (e.g. assumes a minimum of 1/3 contact circumference of tube as shown in Fig. 6c)

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Both outer belt component 32 and inner belt component 31 are constructed so that neither breaks or fails when loaded

during operation of the belt system of the present invention. The belt components stretch or elongate when loaded but do not fail except at extreme loads.

5 Advantages to the two component torso belt of the present invention are to eliminate the decorative cover (i.e., the tubular webbing acts as a load bearing member as well as the outer cover). By reducing the load to the inflatable member lighter weight ( $\leq 6.0$  oz/yd<sup>2</sup>), low denier  
10  $\leq 210$  denier), and low thickness  $\leq 0.009$ " fabrics may be used for the inflatable member. Also, the tubular webbing acts as reinforcement for the sewn connection of the inflatable member to the tubular webbing. Because the yarns used in the manufacture of the tubular webbing are larger (500 to 1300  
15 denier) than that of the inflatable fabric the tubular webbing resists the tearing load action to the sewn connection induced by the pressure created by the inflator as it fills the inflatable member.

20 The tubular outer belt component 32 and the inner inflatable component 31 may be designed to have relative resistance to further elongation as loaded so that the percent tensile loading on the tubular belt component 32 has a selected range with a medium and the percent tensile  
25 loading on the inner component has a selected range with the media of such ranges adding up to about one hundred at various phases of loading from initial deceleration to maximum loading.

30 Since both belt components 31, 32 serve to carry the loads imposed during deceleration each component can be made thinner, lighter and of less strong material than a conventional belt. Inflation rates and amounts and extent of inflation may be varied by varying the size, thickness and  
35 strength of the inner and outer components and by selecting inflators of varying type, size and output. While it is preferred that outer component 32 carry the initial load

prior to its rupture caused by inflation of the inner section other load sharing between such components may be provided. Upon inflation and rupture, it is preferred that inner component 31 takes more and more of the load as the crash event continues. Upon the maximum load being applied during the crash, it is intended that inflated inner component 31 carry over half such load and up to ninety (90%) per cent of the such load.

- 10        When belt 13 is in normal use with occupant buckled up, the torso section 21 of belt 13 visible to occupant has the appearance of convention vehicle restraint belting.

Outer tubular belt component 32 preferably has the physical properties of (1) tensile strength of 3,000-6,700 lbs. (2) elongation of 7-10% at 2,500 lbs. and thickness of 0.025-0.060 inches similar to conventional belt webbing. However, any suitable material can be used provided it can withstand the initial loads until inner component 31 takes up the load burden upon inflation and provided it is readily scorable, or can otherwise be weakened to accomplish proper rupture during inflation. Outer tubular belt section 32 comprises a low denier (50 to 420) woven frangible warp fiber. Fill fibers positioned at approximately right angles to the warp fiber cause the frangible fiber to fail when inflation occurs by pulling on the fiber until it fails.

The outer tubular webbing ranges in thickness from 0.035" to 0.055" and ranges in width from 1.875" to 2.5". The tubular webbing is an uncoated woven polyester hollow webbing. Polyester was chosen for its low elongation and flammability properties.

The elongation of the tubular webbing, alone under a 2,500 lb<sub>f</sub> load is 7% to 10% depending on its thickness and width (i.e., cross-sectional area). Under the same load of 2,500 lb<sub>f</sub> the uninflated pleated inflatable inner member (no

tubular webbing surrounding it) elongates in the ranges of 15.4% to 23.1%. The elongation of the uninflated composite of tubular webbing and pleated inflatable is 7.8% to 8.7%.

- 5 The band assembly including outer and inner members were fixed at one end, inflated to the pressures noted below while loaded in tension using a low strain rate tensile test machine. The data is set out in Table 1.

Table 1

10	Load (Lb.)	Band (psig)	% Elong. <u>Inflatable</u>	% Elong. <u>Split Web</u>
	1,000	11.0	10.76	4.6.
	1,500	12.0	13.8	4.6
	2,000	12.0	13.8	7.7
15	2,500	12.5	16.92	9.2
	4,685	12.0 (Failure)		

- Based on the above data and using elastic modulus to equivocate the relationship between the composite band and its individual components it has been determined that load distribution in the uninflated state is 4 (inflatable) to 1 (webbing). Using the same principle, the load distribution in the inflated state between the individual components is 3 (inflatable) to 1 (split webbing). This change in load distribution results in a 5% to 7% reduction in the longitudinal load transferred to the inflatable. The change in the load distribution is due to some of the load being dispersed radially through the inflated inflatable member.

- 30 The inner inflatable component is preferably constructed of a 210 denier or less nylon or polyester woven fabric coated for air retention purposes with either thermal plastic polyurethane (for ease of heat sealing) or silicone coating. The fabrics currently in use possess the following physical characteristics:

35	Weave Pattern	Plain, 2:1 Twill or Oxford
	Weight (oz./yd <sup>2</sup> )	4.5 - 6.0

6/17/98  
or BASKET  
DHL  
alm  
AD3

6/17/98

Amc  
a Ds  
Dkt

Thickness (inches)

~~0.008~~ 0.007

- 0.009

Tensile Strength (lb)

220 - 280 (Hoop Direction)

275 - 325 (Longitudinal  
Direction)

- 5 The diameter of the inflatable member at 10 psig is about 6 inches.

- 10 The expansion of inner component 31 causes the outer component 32 positioned in belt enclosure 18 to engage the inner surface of enclosures 18, 40 over a distance between inflator 20 and the enclosure exit slots 18s, 40s of enclosures 18s and 40.. This engagement caused by inflation pressure and friction assists in transferring the load to structural seat 10, 10'.

- 15 Outer belt 32 remains in contact with the occupant during operation with the inner component deploying away from and substantially out of contact with the occupant. Outer belt 32 provides an insulation layer between the hot gases in the inner component and the occupant.

- 20 Finally, the dual component belt of the present invention may be utilized in the lap belt section or in both the torso and lap belt sections. A second inflator may be positioned to serve the lap belt section but is not necessary if a run-through buckle tongue is employed.

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## WE CLAIM:

1. In a vehicle having a seat for an occupant, a belt  
5 restraint system comprising

10 a belt member including an outer belt component and  
an inner inflatable belt component which components  
are connected to one another at spaced-apart  
locations;

15 a portion of the outer belt component being  
frangible to create an opening when such portion is  
stressed; and

an inflator in communications with the inflatable  
component for inflating such component;

20 whereby when the inflator inflates the inner inflatable  
component the outer component ruptures due to inflation  
stress creating an opening allowing the inner inflated  
component to exit such opening to provide an inflated belt  
section for occupant restraint.

25 2. In a vehicle having a seat for an occupant, a belt  
restraint system comprising

30 a belt member for restraining the occupant which  
belt member includes an inflatable belt section  
anchored between a first anchor and a second  
anchor;

35 an inflator in communication with the inflatable  
section;

said belt section including an outer belt component  
and an inner inflatable belt component which

components are connected to one another at spaced-apart locations on said belt member; and

5 a portion of the outer belt component being frangible to create an opening when the portion is stressed,

whereby the inflator inflates the inner inflatable component the outer component ruptures creating an opening allowing the  
10 inner inflated component to exit such opening to provide an inflated belt section for occupant restraint.

3. The vehicle occupant belt system of claim 2 in which the inflatable section is a torso section.  
15

4. The vehicle occupant belt system of claim 2 in which the inflatable section is a lap belt section.

5. In a vehicle having a seat for an occupant, a belt  
20 restraint system comprising

a belt member for restraining the occupant which belt member includes an inflatable torso section anchored between a first anchor adjacent the seat  
25 and a second anchor behind the seated occupant;

an inflator;

an inflator in communications with the torso belt  
30 section;

said torso belt section including an outer belt component and an inner inflatable belt component which components are connected to one another a  
35 spaced-apart locations along said torso belt section; and

a portion of the outer belt component being frangible to create an opening when the portion is stressed

5 whereby the inflator inflates the inner inflatable component the outer component ruptures creating an opening allowing the inner inflated component to exit such opening to provide an inflated torso belt section.

10 6. The vehicle occupant belt system of claim 5 in which the belt member includes a lap belt.

7. The vehicle occupant belt system of claim 5 in which a belt guide enclosure is provided between the occupant  
15 and the second anchor.

8. The vehicle belt system of claim 7 in which the inflator is positioned within the torso section located in the enclosure.

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9. In a vehicle having the occupant seat and belt system of claim 4 in which outer belt component comprises a woven fabric with a plurality of longitudinal warp threads and in which the frangible portion is one warp thread that is  
25 weaker than the other warp threads.

10. In a vehicle having the occupant seat and belt system of claim 4 in which the seat has a frame structure and the enclosure is secured to such structure.

30

11. In a vehicle having the occupant seat and belt system of claim 4 in which the seat has an upper back and the guide enclosure has one end adjacent the upper back and another end adjacent the second anchor.

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12. In a vehicle having the occupant seat and belt system of claim 8 in which the weaker thread extends from the

slot to the area adjacent the buckle and is weaker at the end adjacent the buckle than at the end adjacent the slot.

13. In a vehicle having the occupant seat and the belt system of claim 6 in which the vehicle has a frame and the enclosure is secured to such frame.

14. A method of restraining an occupant seated in a vehicle comprising

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1) providing a tubular belt member anchored upon deceleration of the vehicle at two anchor locations with the first anchor adjacent the seat and another anchor at a remote location in the vehicle;

15

2) locating in the tubular belt member an inner inflatable member, said inner inflatable member having two ends and a middle portion with the middle portion extending across the occupant and the ends secured to such belt member;

20

3) providing as part of the tubular belt member a rupturable portion which upon inflation of the inflatable inner member ruptures to permit such inner member to exit the tubular belt; and

25

4) providing an inflator;

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5) locating said inflator in communication with the inner inflatable member so that upon deceleration of the vehicle, the inflator inflates the inflatable inner member which causes it to exit the tubular belt and to assist in decelerating the occupant.

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15. The method of restraining an occupant of claim 14 in which the inner inflatable member extends across the occupant's torso.

5        16. The method of restraining an occupant of claim 14 in which the inner inflatable member extends across the occupant's lap.

17. The method of restraining an occupant of claim 14  
10 including the step of providing a belt enclosure between the occupant and the remote anchor which belt reciprocates in such enclosure.

18. The method of restraining an occupant of claim 14  
15 in which the inflator is located in the inner inflatable member and in the enclosure.

19. The method of restraining an occupant of claim 14 in which the tubular belt member and the inner inflatable  
20 member share the load caused by the decelerating occupant with the belt member carrying a greater load during the first phase of deceleration and prior to the completion inflation of the inner member which carries the greater load after complete inflation.

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20. The method of claim 14 in which the tubular belt member and the inner inflatable member have relative resistance to further elongation as loaded so that the percent tensile loading by the tubular belt and the percent  
30 tensile loading of the inner member up to about one hundred at various phases of loading from initial deceleration to maximum loading.

21. The method of claim 14 in which the tubular belt  
35 member and the inner member have relative resistance to further elongation as loaded by deceleration of occupant with the resistance of the torso belt member being less than the

inner belt member resistance upon rupture of the torso belt member.

22. The method of claim 14 in which the tubular belt member includes fabric and the rupturable portion is a fiber in such fabric.

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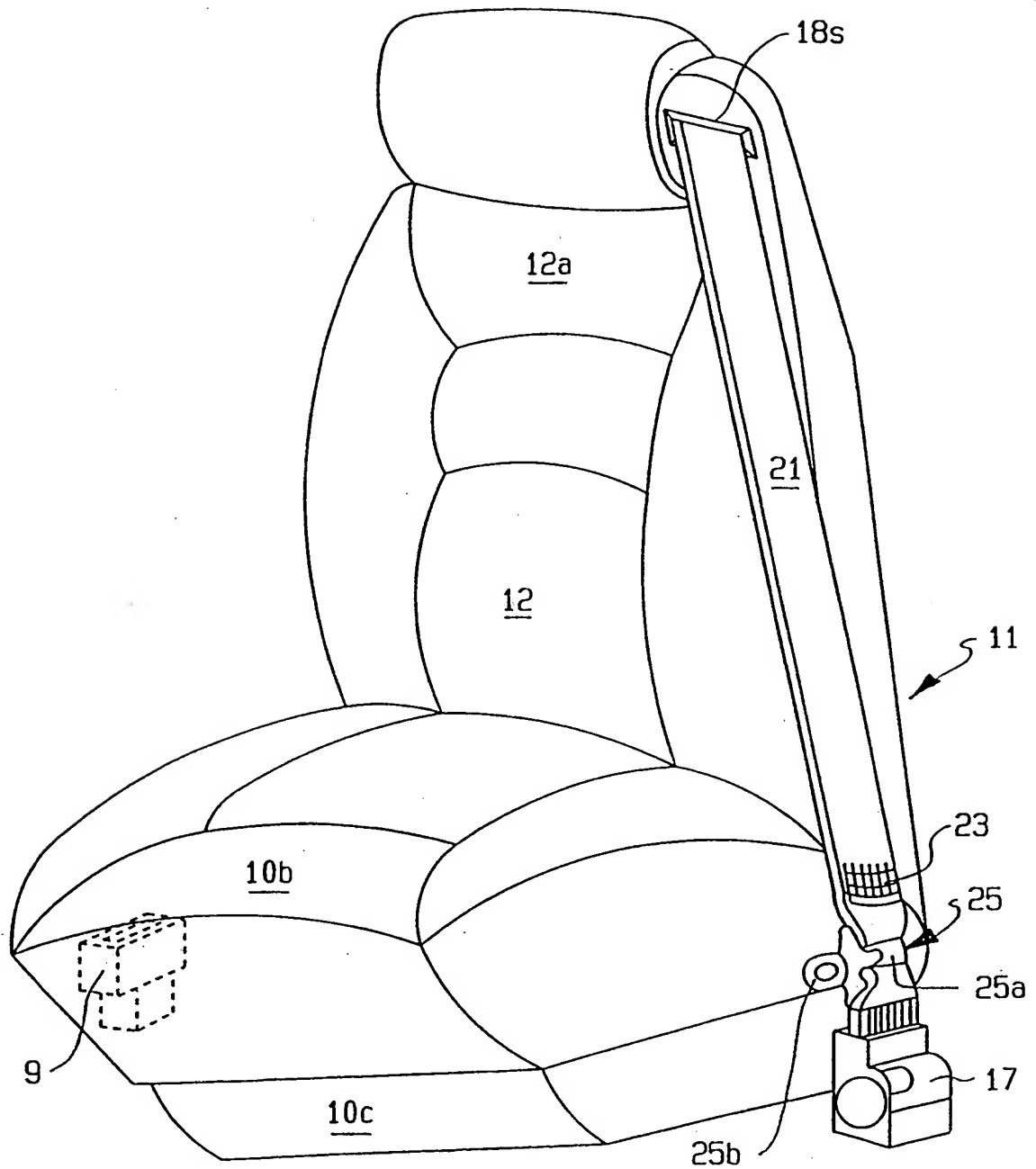


FIG. 1

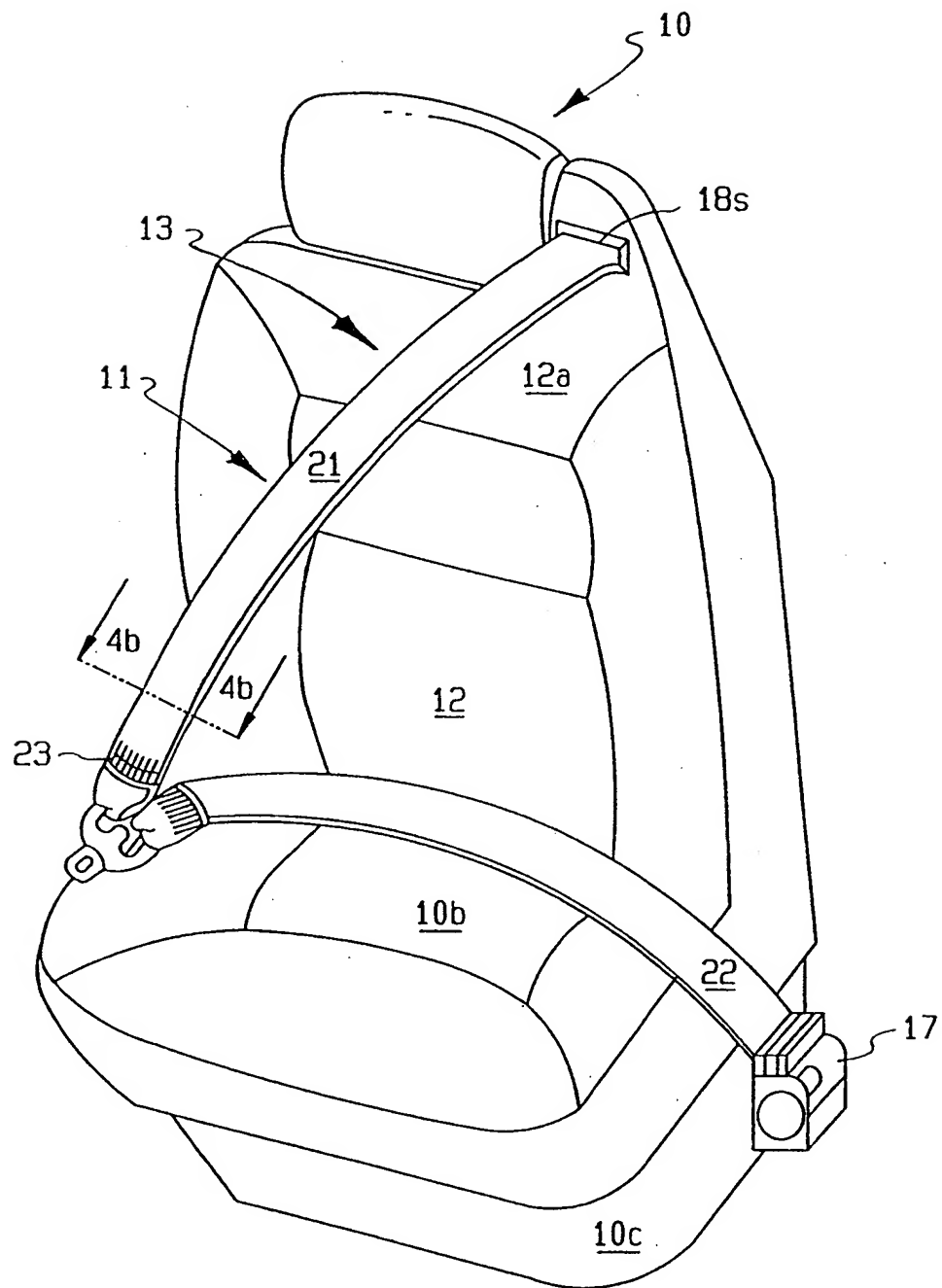
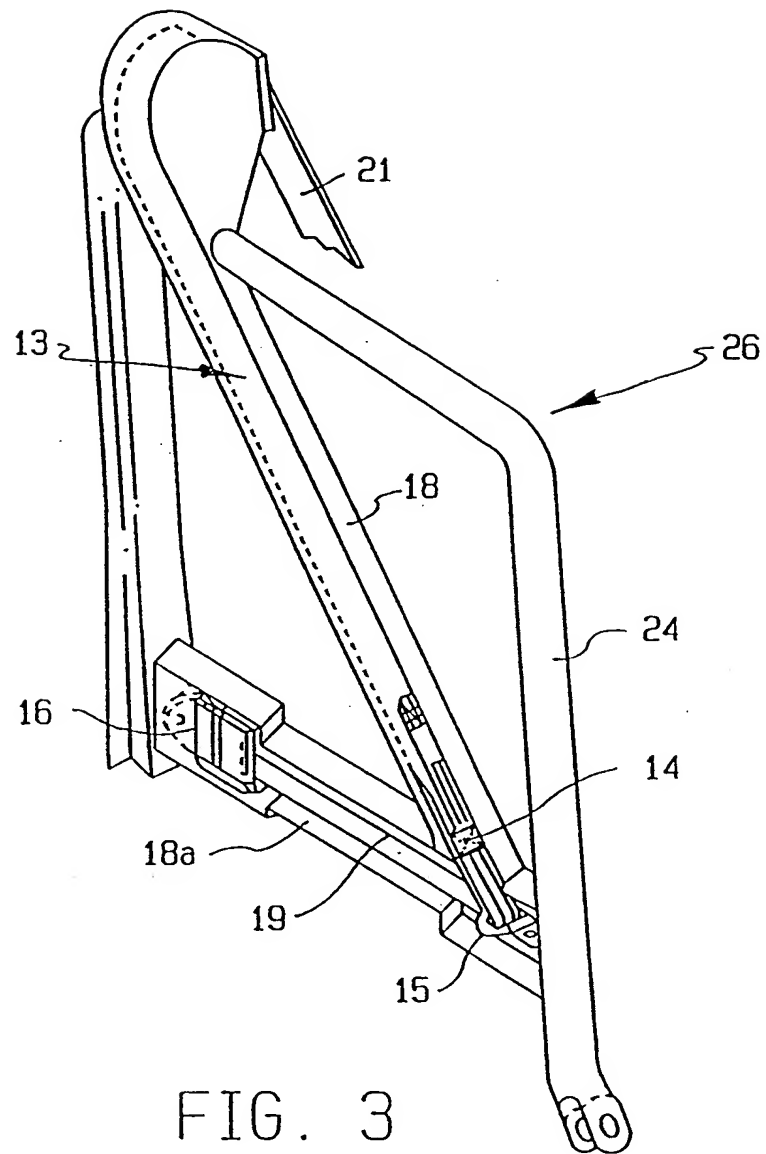


FIG. 2



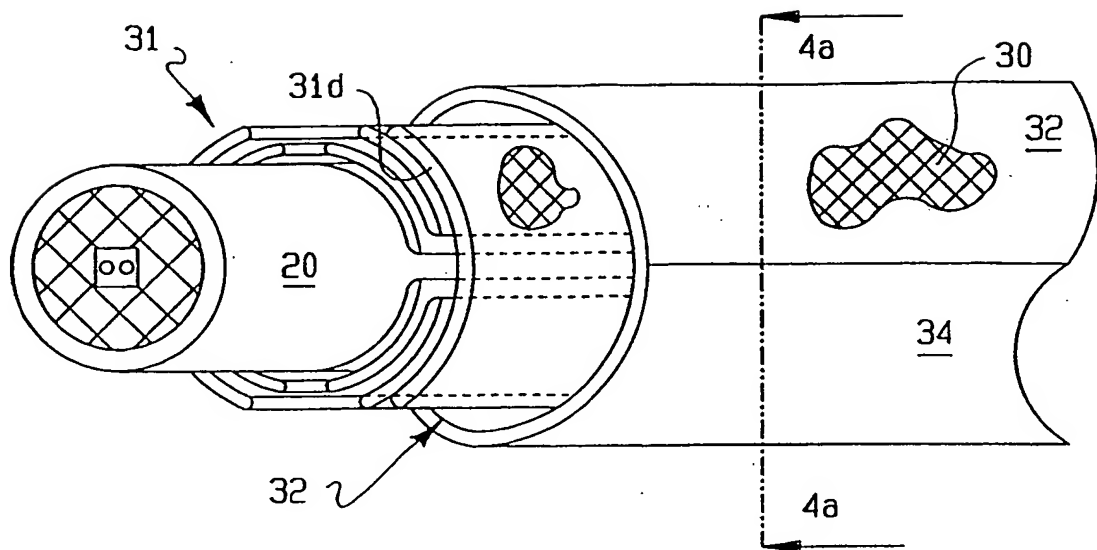


FIG. 4

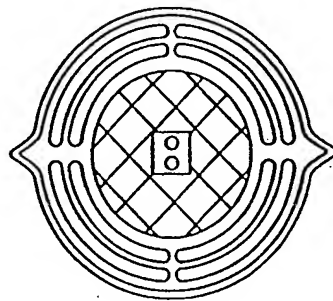


FIG. 4a

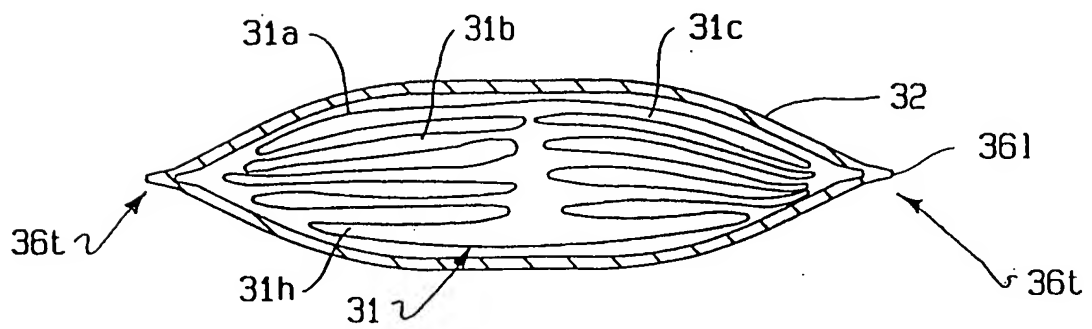


FIG. 4b

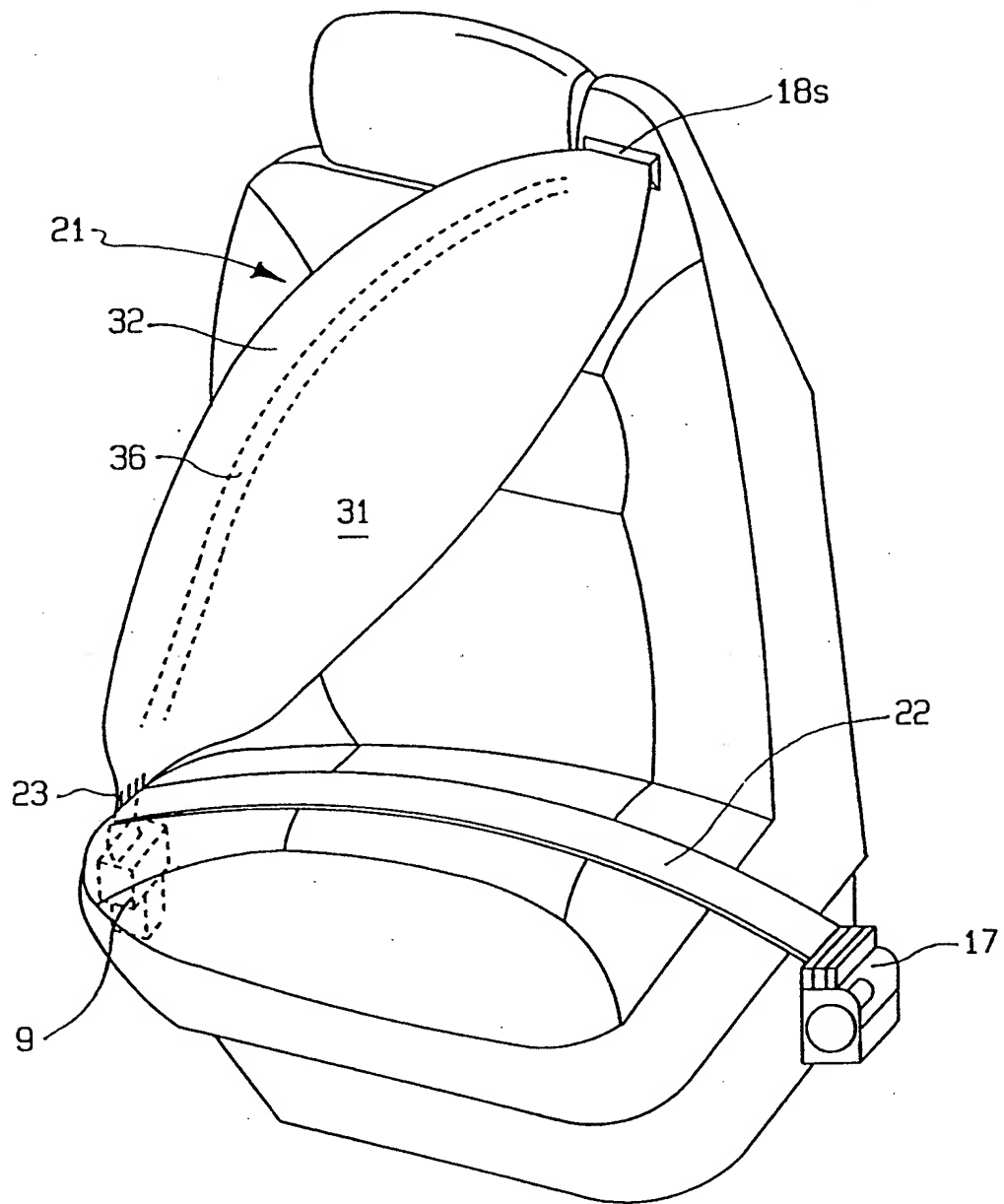


FIG. 5

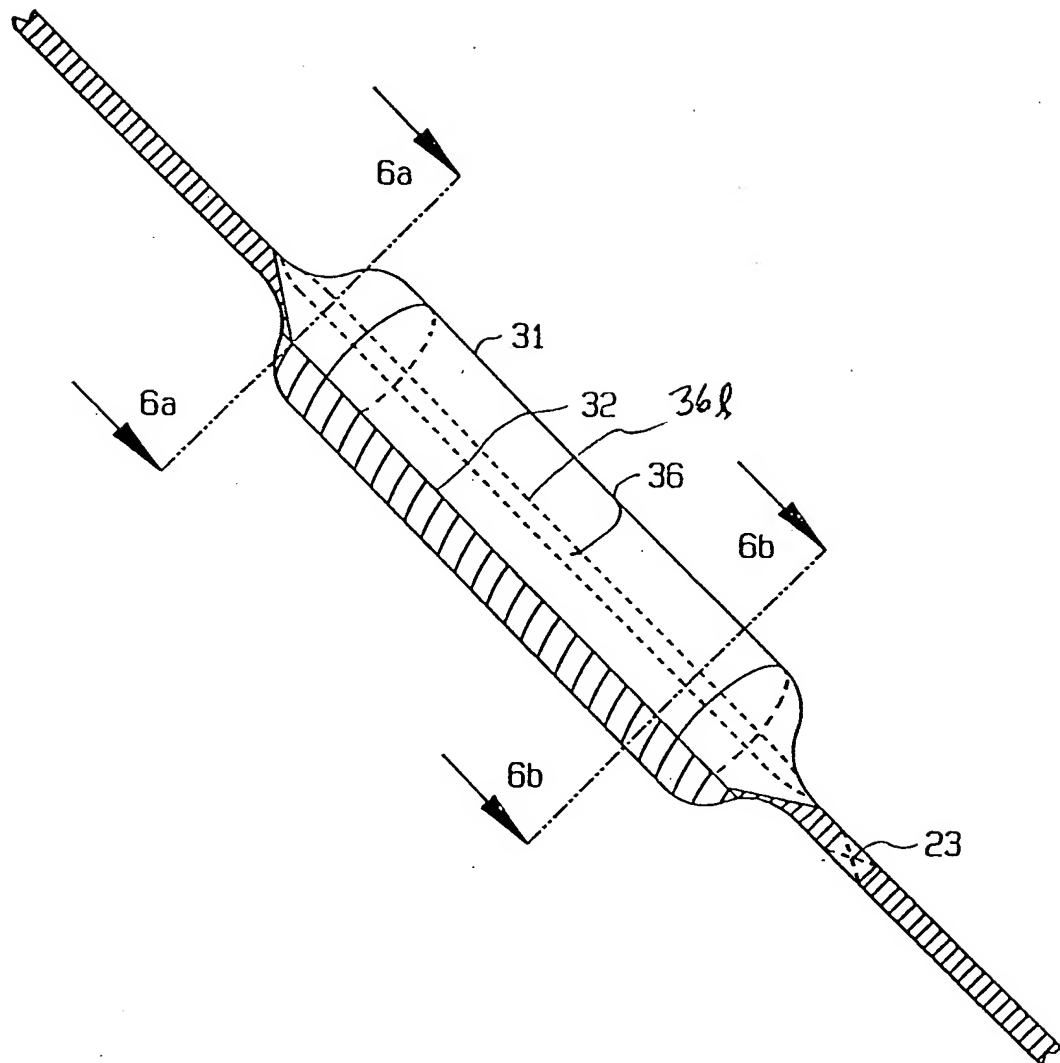


FIG. 6

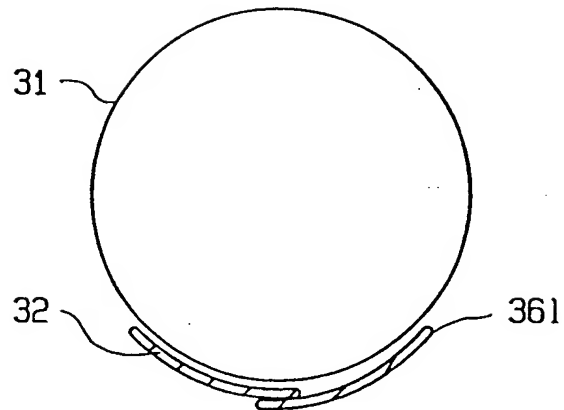


FIG. 6a

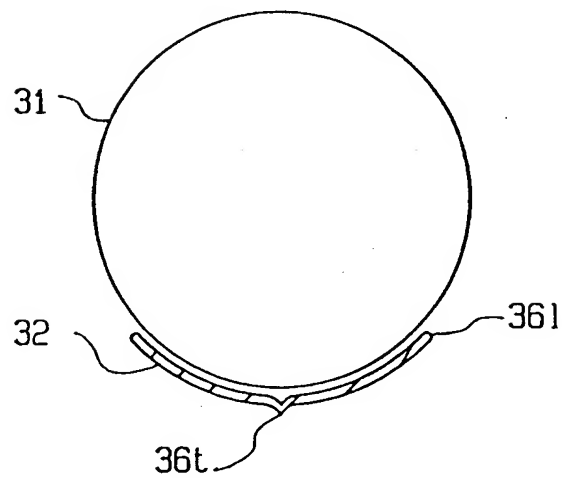


FIG. 6b

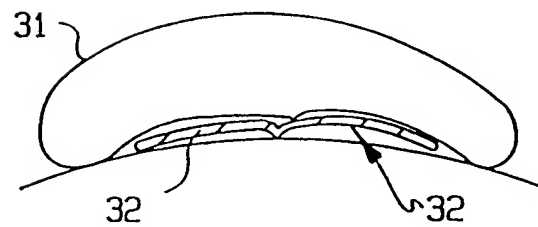


FIG. 6c

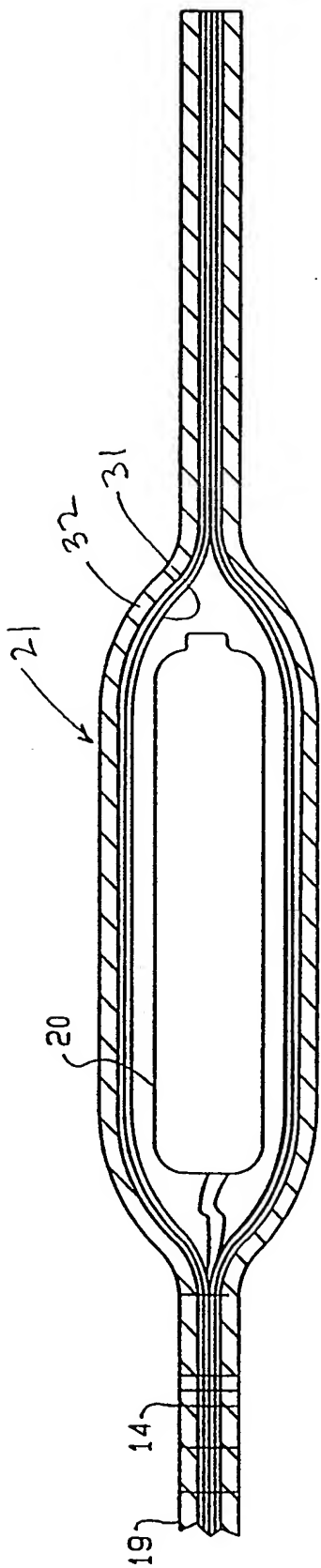


FIG. 7

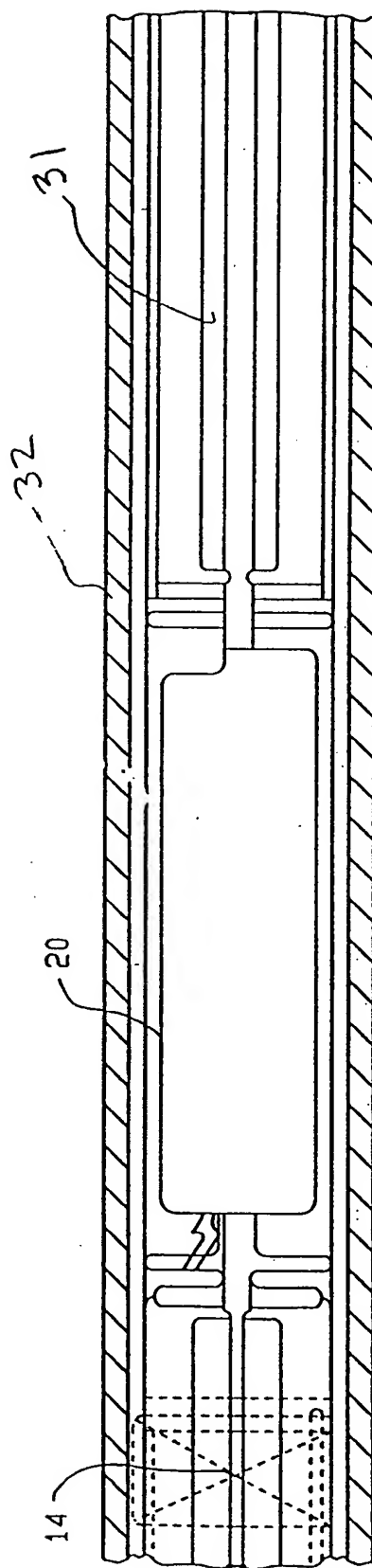


FIG. 8

FIG. 9

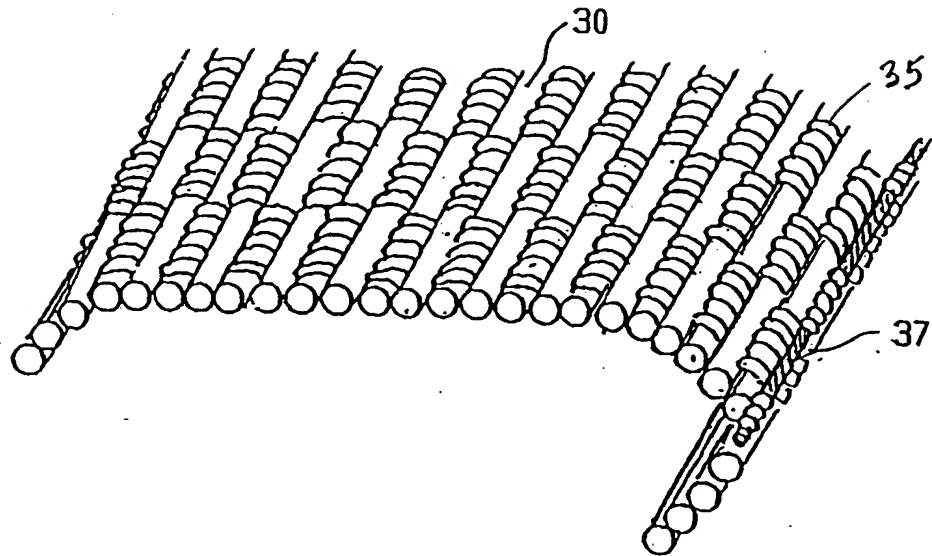
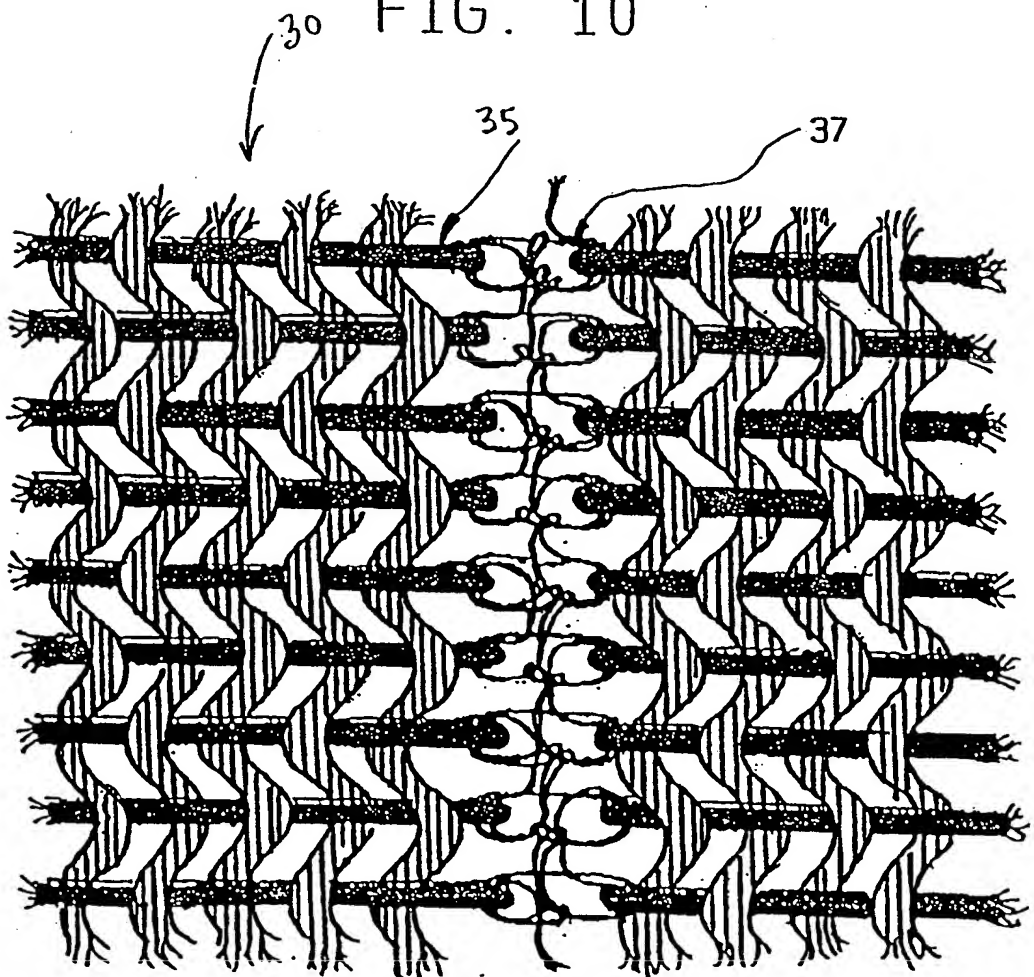


FIG. 10



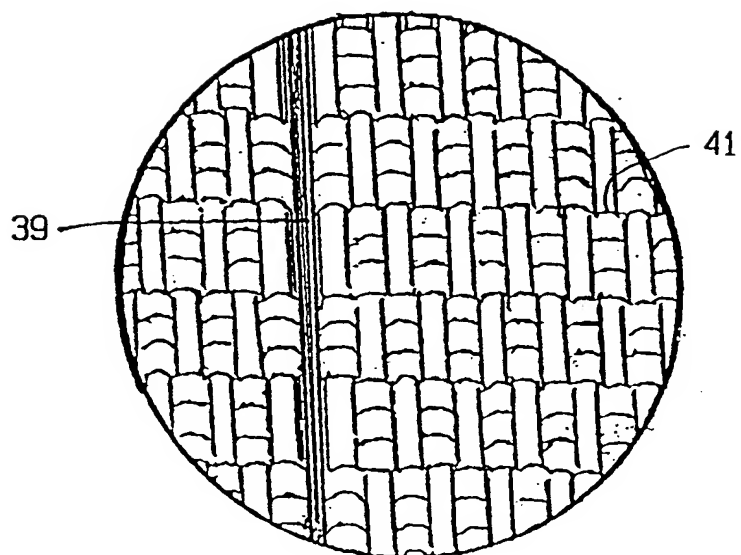


FIG. 11

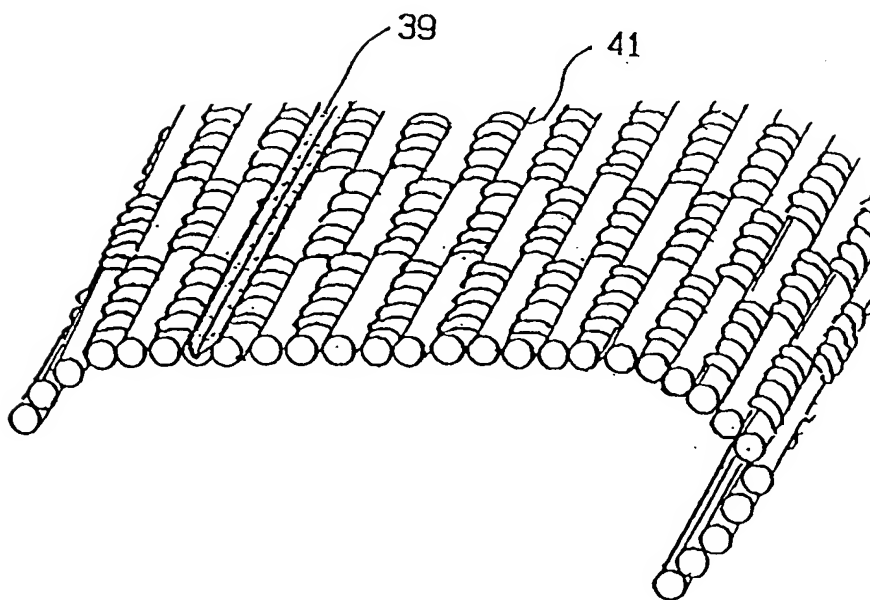


FIG. 12

12/12

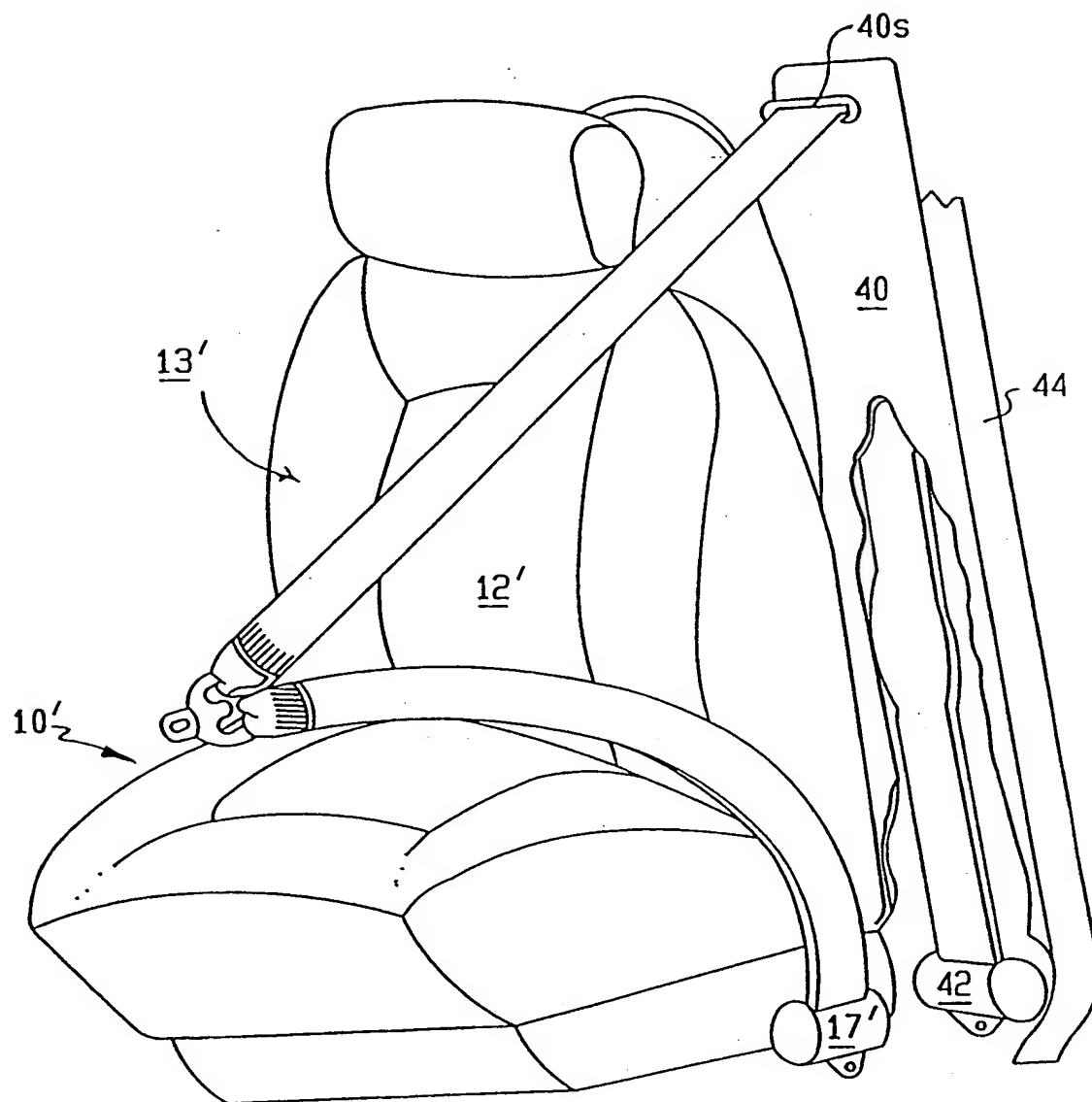


FIG. 13



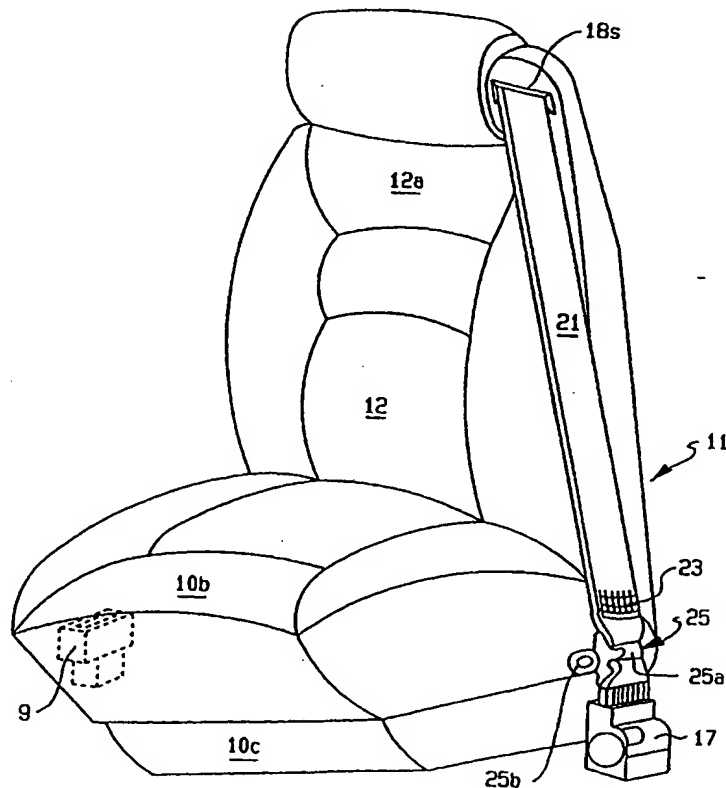
## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup>:</b>  <b>B60R 21/18</b>	<b>A3</b>	<b>(11) International Publication Number:</b> <b>WO 99/65733</b>  <b>(43) International Publication Date:</b> 23 December 1999 (23.12.99)
<b>(21) International Application Number:</b> PCT/US99/13399  <b>(22) International Filing Date:</b> 14 June 1999 (14.06.99)  <b>(30) Priority Data:</b> 09/099,858      18 June 1998 (18.06.98)      US  <b>(71) Applicant:</b> UNIVERSAL PROPULSION COMPANY, INC. [US/US]; 25401 North Central Avenue, Phoenix, AZ 85027-7899 (US).  <b>(72) Inventors:</b> HAMMER, David, R.; 5532 W. Alameda Road, Glendale, AZ 85310 (US). MCCLENATHAN, Robert, V.; 6431 E. Paradise Lane, Scottsdale, AZ 85254 (US). SMITH, A., Gary; 15816 N. 48th Lane, Glendale, AZ 85306 (US).  <b>(74) Agents:</b> MCKENNEY, Charles, E. et al.; Pennie & Edmonds LLP, 1155 Avenue of the Americas, New York, NY 10036 (US).	<b>(81) Designated States:</b> AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims</i> <i>and to be republished in the event of the receipt of amendments.</i>  <b>(88) Date of publication of the international search report:</b> 3 February 2000 (03.02.00)	

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## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/13399

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B60R 21/18

US CL :280/733, 743.1

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 280/733, 743.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- Y	US 5,383,713A (KAMIYAMA et al.) 24 January 1995, fig. 2.	1-6, 9-16, 18-22 ----- 7, 8, 17
Y, P	US 5,851,055 A (LEWIS) 22 December 1998, fig. 2.	7, 8, 17
A, P	US 5,839,753 A (YANIV et al.) 24 November 1998, figs. 1-2.	1-22
A	US 4,348,037 A (LAW et al.) 07 September 1982, fig. 3.	1-22
A	US 4,741,574 A (WEIGHTMAN et al.) 03 May 1988, fig. 5.	1-22

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* *A* *E* *L* *O* *P*	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance earlier document published on or after the international filing date document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) document referring to an oral disclosure, use, exhibition or other means document published prior to the international filing date but later than the priority date claimed	*T* *X* *Y* *&*	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art document member of the same patent family
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01 NOVEMBER 1999

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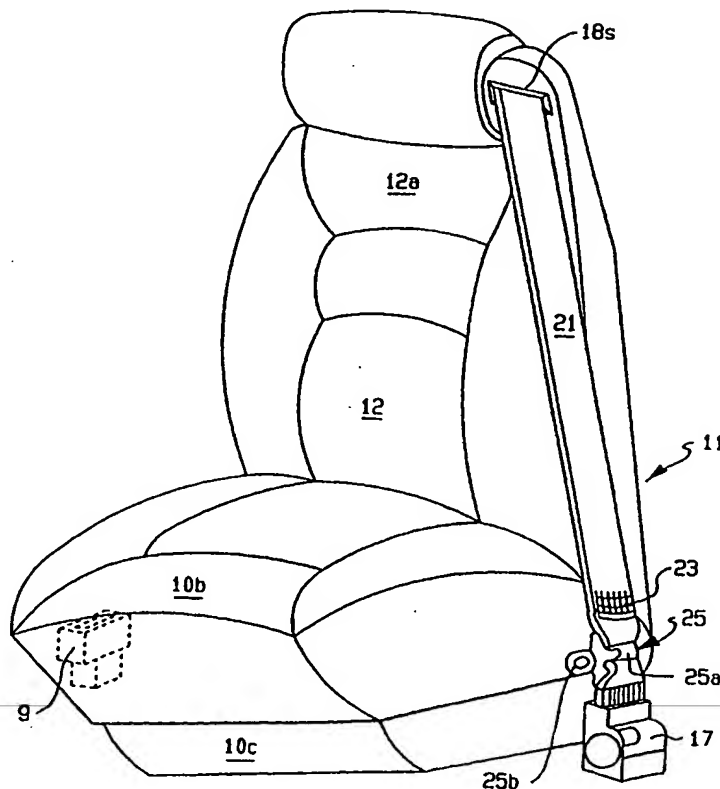
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## INFLATABLE SEAT BELT WITH INNER AND OUTER MEMBERS

Background of Invention

5 Inflatable seat belts have included perforated fabrics (U.S. Patent No. 3,801,156)). Other belts have included folded woven fabric bodies within a rupturable cover (U.S. Patent No. 5,346,250). Inflatable belts have been pleated and stitched for use prior to inflation reinforcing material  
10 (U.S. Patent No. 3,866,940).

Prior inflatable seat belts have included decorative covers which had little or no load bearing ability. Further, the attachment between the inflatable sections and the non-  
15 inflatable sections in prior belts lacked sufficient reinforcement to withstand the high loading occurring during a crash.

Summary of the Invention

20 Broadly, the present invention comprises a vehicle seat and seat belt system including (1) a tubular webbing made of fabric or other suitable material having strength characteristics, not unlike a conventional seat belting, and (2) having an inflatable tube, bladder or other inflatable  
25 component positioned in the tubular webbing. The outer tubular webbing component is longitudinally frangible to allow the inner inflatable component, as it is inflates, to exit through a rupture opening in the tubular webbing during the period of vehicle deceleration pending a crash. The  
30 pressure and forces of the inflation of the inner component cause the outer tubular webbing to rupture. The combination of outer tubular webbing and inner inflatable component may be used in a torso section, a lap section or both.

35 The belt system may be used in combination with a structural seat having a frame in which a belt enclosure and anchor are positioned behind the occupant and secured to the

seat frame. The enclosure houses the torso section of the belt system which torso section includes the outer and inner belt components. An inflator may be positioned within the inner inflatable components. The amount of belting withdrawn  
5 from the enclosure depends on the size of the occupant as he or she buckles up.

Alternatively, the belt enclosure and anchor may be mounted on other portions of the vehicle including its frame.

10

Brief Description of the Drawings

Fig. 1 is a perspective view of the vehicle seat with a belt system of the present invention;

15 Fig. 2 is the same view of Fig. 1 in which the belt system is being buckled up around and without the occupant being shown;

Fig. 3 is a rear perspective view of the seat frame,  
20 rear belt enclosure and anchor mounted to the seat;

Fig. 4 is a broken-away perspective view of that portion of the belt including an inflator which portion resides in the belt enclosure;

25

Fig. 4a is a sectional view taken along line 4a-4a of Fig. 4;

Fig. 4b is a sectional view taken along line 4b-4b of  
30 Fig. 2;

Fig. 5 is a perspective view of the seat of Fig. 1 with the torso section of the belt system inflated;

Fig. 6 is a side sectional elevation view of the torso  
35 belt section inflated;

Fig. 6a is a sectional view through line 6a-6a of Fig. 6;

Fig. 6b is a sectional view along line 6b-6b of Fig. 6;

Fig. 6c is a sectional view similar to Fig. 6b after inflation and the load of the occupant's torso applied against the inflated belt component;

Fig. 7 is a side sectional view of the torso belt portion prior to activation of the inflator;

Fig. 8 is an enlarged view of the torso belt with a tubular outer belt expanded by inflation of the inner component as supplied with gas;

Fig. 9 is a perspective view of a portion of the fabric of the outer tubular belt component;

Fig. 10 is a plan view of the portion and the fabric of the outer tubular belt component;

Fig. 11 is a plan view of a portion of the alternative fabric of the outer belt component;

Fig. 12 is a perspective view of the alternative fabric; and

Fig. 13 is a perspective view of another embodiment of the present invention in which the belt enclosure is mounted adjacent the seat on the vehicle frame.

#### Detailed Description of the Invention

With respect to Figs. 1-3, vehicle structural seat includes a belt system 11 in turn comprising occupant restraint belt 13 including torso section 21 and lap section 22. Torso section 21 has, in its unbuckled mode, two (2)

ends with one end connected to back take-up retractor anchor reel 16 positioned behind a seated occupant (Fig. 3) and the other end connected to a side anchored buckle 9 (Fig. 1).

Torso belt section 21 reciprocally moves in belt guide

5 enclosure 18 as the length of belt component 19 pays out and back into retractor anchor 16. Belt enclosure 18 and anchor 16 are secured to seat frame 24.

Torso belt section 21 includes tandemly connected rear  
10 belt portion 19 (which changes direction as it passes around guide ring 15). Torso belt section 21 extends from belt stitching 23 adjacent seat side reel anchor 17 upwardly alongside the occupant's torso into enclosure slot 18s and includes belt portion 19 attached by stitching 14. Belt  
15 portion 19 is preferably made of conventional belt webbing. Inflator 20 is held within belt section 21 and moves along with torso belt portion 21 as it reciprocates. The position of inflator 20 in the buckled up mode therefore depends on the amount of belt component 21 utilized by the occupant as  
20 he or she buckles up which amount varies with the occupant's size and shape.

Lap belt section 22 has a tongue connector 25 with belt holding opening 25a and tongue 25b. Vehicle seat 10 also  
25 includes seat portion 10a, back portion 12 with upper back portion 12a, base portion 10c and frame 26 (Fig. 3). A structural seat including enclosure belt guides is described in pending U.S. Application Serial No. 08/815,658 filed March 13, 1997 entitled "Inflatable Passenger-Size Adjustable Torso  
30 Belt System Including Enclosure Mount and Method of Passenger Restraint", which application is incorporated here by reference. Also shown is guide enclosure 18, upper enclosure slot opening 18s and gas-creating and discharging inflator 20.

35

Turning now to Figs. 4-6, torso belt section 21 includes an outer tubular belt component 32 and an inner belt

component 31 which inner component 31 is folded for storage within outer component 32. Inner inflatable component 31, when inflated, has a diameter to width of outer belt component 32 ratio in the range of three (3) to four (4) 5 which range may be as high as five (5) or six (6). Component 31 as stored includes folds 31a-31h (Figs. 4, 4a and 4b). Fig. 4a shows a belt cross section within enclosure 18 while Fig. 4b shows a cross section of the belt section 21 across the occupant's torso. Belt component 32 has tits 32t 10 on either side. Frangible line (fiber) 36l lies in one of tits 36t. Torso belt inflation should be large enough in diameter and length to push the occupant back in his or her seat but not large enough to press occupant against the seat to the extent injury would occur due to such torso belt 15 inflation. As a crash event loads torso belt section 21, the load is shared by both (1) the outer tubular component 32 and (2) the inner inflated (partially or completely) component 31. Partial inflation occurs within enclosure 18 due to the restraint enclosure 18 provides.

20

In the first and earliest phase of a crash, inflator 20 is caused to supply gases to inner component 31 which starts to inflate exerting pressure on the inner walls of outer component 32. When the pressure reaches a certain level the 25 outer component 32 ruptures along frangible line 36l and the inner belt portion 31 starts to exit through the ruptured area 36 (Fig. 5). Frangible line 36l is preferably along an edge of inner component 32 (Fig. 4a). The rupturing of outer belt component 32 substantially reduces its ability to 30 withstand loads without substantial elongation.

As vehicle and occupant deceleration continues, outer belt component 32 begins to stretch due to forces created by the occupant while at the same time the inner belt component 35 31 begins to pretension and foreshorten as it takes up a portion of the load. In the next phase when the inflating component 31 has deployed further, inner belt component 31

takes more load and the outer belt component 32 carries less load. Finally, when the inner component 31 is fully deployed, the inner component 31 assumes substantially all the load (from 60%-90%). Since outer and inner components 5 share the crash load, each can be made thinner, lighter and of lower strength than a conventional vehicle restraint belting. Components 31, 32 may be made of any suitable material. The preferred material is woven fabric such from polyester or nylon fibers or threads. The outer tubular 10 section 32 has a strength of 3,000 to 6,700 lbs. and an elongation of less than 10% at 2,500 lbs. Frangible warp fiber 37 has a low denier of 50 to 420.

Full inflation of torso belt 21 occurs between stitching 15 23 (Fig. 5) and stitching 14 (Fig. 3) with inflation of the inner component 31 and its deployment outside outer component 32 occurring between stitching 23 and enclosure exit 18s (Fig. 5).

20 Figs. 6, 6a, 6b and 6c show the outer belt webbing component 32 deployed through slot 36 formed by the rupture of outer belt component 32. Limited inflation occurs within belt enclosure 18 utilizing some of the gases discharged by inflator 20 but the great majority of gases provided by 25 inflator 20 inflate the portion of inner component 31 shown in Figs. 5 and 6 for torso restraint.

In Fig. 6c, the operation of deployed inner inflated component 31 after outer component 32 has stretched due to 30 its weakened condition includes component 31 coming into contract with occupant's torso (T) to arrest forward torso movement. The shape of inflated component 31 is changed from circular to oval shaped by the forces required to arrest the occupant's torso (T).

35

Fig. 7 illustrates the location of inflator 20 within torso belt 21 prior to inflation and Fig. 8 shows the torso

belt 21 inflated within the restraints of the inner walls 18w of enclosure 18.

Fig. 9 shows a woven fabric portion 30 of tubular belt 5 section 32 with longitudinal fiber or thread 37 which fails due to tension in cross or fill fibers 35. Fig. 10 in an enlarged view illustrating fabric portion 30. Inflation causes cross fill fibers 35 to pull on frangible thread 37 to cause it to rupture creating longitudinal opening 36.

10

In Figs. 11 and 12 an alternative arrangement for providing pressure induced rupture of the tubular webbing component 32 is shown in which fiber 39 is preweakened by chemical etch or laser light. Of course, fibers can be 15 weakened by reduction of fiber cross-section. Alternatively, the webbing may be weakened by a hot knife or wire or by water jet. Seam 39 is broken by the pulling of fill fibers 41.

20 Turning to Fig. 13, an alternative embodiment is shown in which belt 13' passes into a belt enclosure 40 positioned adjacent seat 10'. Enclosure 40 is attached to vehicle frame pillar 44. Enclosure 40 includes an upper slot opening 40s and a belt take-up anchor 42. Also shown are seat 10', seat 25 back 12' and side take-up reel 17'.

In operation of restraint belt 13 including its torso section 21, an occupant sits in seat 10 and he or she pulls tongue connector 25 having tongue 25b over his or her lap and 30 inserts tongue 25b in lap right side buckle receiver 14 (Fig. 1). As this buckling up step is carried out, torso belt section 21 including its hidden rear web portion 19 pays out of retractor anchor 16. At the same time lap belt section 22 pays out of anchor 17. The amount of belt pay out depends on 35 the occupant, with more belt being payed out for a larger occupant than a smaller occupant. Inflatable torso section 21 which pays off anchor 16 exits guide enclosure slot 18s,

in upper seat back 12a (Fig. 2). Belt system 13 is designed so that inflator 20 and a length of attached belt 19 remain in the belt guide enclosure 18, even when the largest occupant is being accommodated.

5

In further operation of the system during a crash event when the vehicle experiences rapid deceleration, a crash sensor (not shown) activates inflator 20 which discharges gases into inner belt component 31. Anchors 16, 17 lock up  
10 preventing any additional belt pay out. Since inflator 20 is located in enclosure 18 behind seat 10 or adjacent the seat in enclosure 40, the gases first discharged from inflator 20 expand inner component 31 to the extent it can expand within the confines of enclosure 18. Since enclosure 18 restrains  
15 belt section expansion, inner section 31 does not emerge from outer belt section 32 even if section 32 develops a frangible split due to internal gas pressures.

Once belt section 21 in enclosure 18 has been inflated  
20 to the extent permissible, further discharged gases serve to inflate the torso belt section 21 outside enclosure 18 and adjacent the occupant's torso. When pressure in the torso belt 21 outside enclosure 18 reaches a certain level, frangible fibers in outer belt component 32 break causing  
25 component 32 to rupture at a point and then rapidly along the longitudinal length of the belt component 32 between slots 18s and stitching 23 (Fig. 5) creating rupture opening 36. Fiber 37 varies in strength along its length with its weaker portion being at the lower torso end adjacent stitching 23  
30 remote from the area of occupant's head and slot 18s. Such variation in fiber strength causes emergence of the inner belt component 31 at the area just above stitching 23 prior to its emergence at the area adjacent the occupant's head.

35 During vehicle deceleration and phases of inflation of torso belt section 21 the system functions to decelerate the occupant as follows:

1. Outer belt component 32 being in engagement with the occupant's torso resists occupant's forward motion. The area (width times length) of outer belt 32 (which is initially loaded by occupant's movement) is an area  
5 equal to or substantially equal to the area of the outer belt 32 prior to any inflation. Such area in contact with the torso is in the range of 50 to 68 in<sup>2</sup>.

2. Upon the onset of inflation of the inner torso component 31 and the rupture of outer belt component 32,  
10 outer component 32 is reduced in strength due to the rupture-created slot 36 (Figs. 5 and 6). As the occupant is decelerated component 32 elongates and narrows.

3. As outer belt component 32 elongates and narrows, inner inflated component 31 is expanding laterally as it is inflated causing it to shorten. Further component 31 as it shortens is subjected to the  
15 load exerted by the occupant which load becomes greater than the load on the outer section.

4. By the time inner belt section 31 is fully inflated and occupant deceleration is reaching a point  
25 where a maximum load is being placed on belt system 11, the inner component 31 serves as the principal occupant restraint. Inner belt component 31, also made of fabric or similar material, stretches as it is loaded providing in its inflated state, a cushioning effect against  
30 occupant's torso. Upon full inflation, the area of belt contact with the torso is in the range of 150-180 in<sup>2</sup> depending on the width of tubular webbing 31 and the size of the occupant (e.g. assumes a minimum of 1/3 contact circumference of tube as shown in Fig. 6c)

35 Both outer belt component 32 and inner belt component 31 are constructed so that neither breaks or fails when loaded

during operation of the belt system of the present invention. The belt components stretch or elongate when loaded but do not fail except at extreme loads.

5 Advantages to the two component torso belt of the present invention are to eliminate the decorative cover (i.e., the tubular webbing acts as a load bearing member as well as the outer cover). By reducing the load to the inflatable member lighter weight ( $\leq 6.0$  oz/yd<sup>2</sup>), low denier  
10  $\leq 210$  denier), and low thickness  $\leq 0.009$ " fabrics may be used for the inflatable member. Also, the tubular webbing acts as reinforcement for the sewn connection of the inflatable member to the tubular webbing. Because the yarns used in the manufacture of the tubular webbing are larger (500 to 1300  
15 denier) than that of the inflatable fabric the tubular webbing resists the tearing load action to the sewn connection induced by the pressure created by the inflator as it fills the inflatable member.

20 The tubular outer belt component 32 and the inner inflatable component 31 may be designed to have relative resistance to further elongation as loaded so that the percent tensile loading on the tubular belt component 32 has a selected range with a medium and the percent tensile  
25 loading on the inner component has a selected range with the media of such ranges adding up to about one hundred at various phases of loading from initial deceleration to maximum loading.

30 Since both belt components 31, 32 serve to carry the loads imposed during deceleration each component can be made thinner, lighter and of less strong material than a conventional belt. Inflation rates and amounts and extent of inflation may be varied by varying the size, thickness and  
35 strength of the inner and outer components and by selecting inflators of varying type, size and output. While it is preferred that outer component 32 carry the initial load

prior to its rupture caused by inflation of the inner section other load sharing between such components may be provided. Upon inflation and rupture, it is preferred that inner component 31 takes more and more of the load as the crash event continues. Upon the maximum load being applied during the crash, it is intended that inflated inner component 31 carry over half such load and up to ninety (90%) per cent of the such load.

- 10 When belt 13 is in normal use with occupant buckled up, the torso section 21 of belt 13 visible to occupant has the appearance of convention vehicle restraint belting.

Outer tubular belt component 32 preferably has the physical properties of (1) tensile strength of 3,000-6,700 lbs. (2) elongation of 7-10% at 2,500 lbs. and thickness of 0.025-0.060 inches similar to conventional belt webbing. However, any suitable material can be used provided it can withstand the initial loads until inner component 31 takes up the load burden upon inflation and provided it is readily scorable, or can otherwise be weakened to accomplish proper rupture during inflation. Outer tubular belt section 32 comprises a low denier (50 to 420) woven frangible warp fiber. Fill fibers positioned at approximately right angles to the warp fiber cause the frangible fiber to fail when inflation occurs by pulling on the fiber until it fails.

The outer tubular webbing ranges in thickness from 0.035" to 0.055" and ranges in width from 1.875" to 2.5". The tubular webbing is an uncoated woven polyester hollow webbing. Polyester was chosen for its low elongation and flammability properties.

The elongation of the tubular webbing, alone under a 2,500 lb<sub>f</sub> load is 7% to 10% depending on its thickness and width (i.e., cross-sectional area). Under the same load of 2,500 lb<sub>f</sub> the uninflated pleated inflatable inner member (no

tubular webbing surrounding it) elongates in the ranges of 15.4% to 23.1%. The elongation of the uninflated composite of tubular webbing and pleated inflatable is 7.8% to 8.7%.

- 5        The band assembly including outer and inner members were fixed at one end, inflated to the pressures noted below while loaded in tension using a low strain rate tensile test machine. The data is set out in Table 1.

Table 1

10	Load	Band	% Elong.	% Elong.
	<u>(Lb<sub>r</sub>)</u>	<u>(psig)</u>	<u>Inflatable</u>	<u>Split Web</u>
	1,000	11.0	10.76	4.6.
	1,500	12.0	13.8	4.6
	2,000	12.0	13.8	7.7
	2,500	12.5	16.92	9.2
15	4,685	12.0 (Failure)		

- Based on the above data and using elastic modulus to equivocate the relationship between the composite band and its individual components it has been determined that load distribution in the uninflated state is 4 (inflatable) to 1 (webbing). Using the same principle, the load distribution in the inflated state between the individual components is 3 (inflatable) to 1 (split webbing). This change in load distribution results in a 5% to 7% reduction in the longitudinal load transferred to the inflatable. The change in the load distribution is due to some of the load being dispersed radially through the inflated inflatable member.

- The inner inflatable component is preferably constructed of a 210 denier or less nylon or polyester woven fabric coated for air retention purposes with either thermal plastic polyurethane (for ease of heat sealing) or silicone coating.

The fabrics currently in use possess the following physical characteristics:

	Weave Pattern	Plain, 2:1 Twill or Oxford or Basket
5	Weight (oz./yd <sup>2</sup> )	4.5 - 6.0
	Thickness (inches)	0.007 - 0.009
	Tensile Strength (lb)	220 - 280 (Hoop Direction) 275 - 325 (Longitudinal Direction)

The diameter of the inflatable member at 10 psig is  
10 about 6 inches.

The expansion of inner component 31 causes the outer  
component 32 positioned in belt enclosure 18 to engage the  
inner surface of enclosures 18, 40 over a distance between  
15 inflator 20 and the enclosure exit slots 18s, 40s of  
enclosures 18s and 40.. This engagement caused by inflation  
pressure and friction assists in transferring the load to  
structural seat 10, 10'.

Outer belt 32 remains in contact with the occupant  
20 during operation with the inner component deploying away from  
and substantially out of contact with the occupant. Outer  
belt 32 provides an insulation layer between the hot gases in  
the inner component and the occupant.

25 Finally, the dual component belt of the present  
invention may be utilized in the lap belt section or in both  
the torso and lap belt sections. A second inflator may be  
positioned to serve the lap belt section but is not necessary  
if a run-through buckle tongue is employed.

30

## WE CLAIM:

1. In a vehicle having a seat for an occupant, a belt  
5 restraint system comprising

10 a belt member including an outer belt component and  
an inner inflatable belt component which components  
are connected to one another at spaced-apart  
locations;

15 a portion of the outer belt component being  
frangible to create an opening when such portion is  
stressed; and

an inflator in communications with the inflatable  
component for inflating such component;

20 whereby when the inflator inflates the inner inflatable  
component the outer component ruptures due to inflation  
stress creating an opening allowing the inner inflated  
component to exit such opening to provide an inflated belt  
section for occupant restraint.

25 2. In a vehicle having a seat for an occupant, a belt  
restraint system comprising

30 a belt member for restraining the occupant which  
belt member includes an inflatable belt section  
anchored between a first anchor and a second  
anchor;

35 an inflator in communication with the inflatable  
section;

said belt section including an outer belt component  
and an inner inflatable belt component which

components are connected to one another at spaced-apart locations on said belt member; and

5 a portion of the outer belt component being frangible to create an opening when the portion is stressed,

whereby the inflator inflates the inner inflatable component the outer component ruptures creating an opening allowing the  
10 inner inflated component to exit such opening to provide an inflated belt section for occupant restraint.

3. The vehicle occupant belt system of claim 2 in which the inflatable section is a torso section.  
15

4. The vehicle occupant belt system of claim 2 in which the inflatable section is a lap belt section.

5. In a vehicle having a seat for an occupant, a belt  
20 restraint system comprising

a belt member for restraining the occupant which belt member includes an inflatable torso section anchored between a first anchor adjacent the seat  
25 and a second anchor behind the seated occupant;

an inflator;

an inflator in communications with the torso belt  
30 section;

said torso belt section including an outer belt component and an inner inflatable belt component which components are connected to one another a  
35 spaced-apart locations along said torso belt section; and

a portion of the outer belt component being frangible to create an opening when the portion is stressed

5 whereby the inflator inflates the inner inflatable component the outer component ruptures creating an opening allowing the inner inflated component to exit such opening to provide an inflated torso belt section.

10 6. The vehicle occupant belt system of claim 5 in which the belt member includes a lap belt.

7. The vehicle occupant belt system of claim 5 in which a belt guide enclosure is provided between the occupant  
15 and the second anchor.

8. The vehicle belt system of claim 7 in which the inflator is positioned within the torso section located in the enclosure.

20

9. In a vehicle having the occupant seat and belt system of claim 4 in which outer belt component comprises a woven fabric with a plurality of longitudinal warp threads and in which the frangible portion is one warp thread that is  
25 weaker than the other warp threads.

10. In a vehicle having the occupant seat and belt system of claim 4 in which the seat has a frame structure and the enclosure is secured to such structure.

30

11. In a vehicle having the occupant seat and belt system of claim 4 in which the seat has an upper back and the guide enclosure has one end adjacent the upper back and another end adjacent the second anchor.

35

12. In a vehicle having the occupant seat and belt system of claim 8 in which the weaker thread extends from the

slot to the area adjacent the buckle and is weaker at the end adjacent the buckle than at the end adjacent the slot.

13. In a vehicle having the occupant seat and the belt system of claim 6 in which the vehicle has a frame and the enclosure is secured to such frame.

14. A method of restraining an occupant seated in a vehicle comprising

10

1) providing a tubular belt member anchored upon deceleration of the vehicle at two anchor locations with the first anchor adjacent the seat and another anchor at a remote location in the vehicle;

15

2) locating in the tubular belt member an inner inflatable member, said inner inflatable member having two ends and a middle portion with the middle portion extending across the occupant and the ends secured to such belt member;

20

3) providing as part of the tubular belt member a rupturable portion which upon inflation of the inflatable inner member ruptures to permit such inner member to exit the tubular belt; and

25

4) providing an inflator;

30

5) locating said inflator in communication with the inner inflatable member so that upon deceleration of the vehicle, the inflator inflates the inflatable inner member which causes it to exit the tubular belt and to assist in decelerating the occupant.

35

15. The method of restraining an occupant of claim 14 in which the inner inflatable member extends across the occupant's torso.

5 16. The method of restraining an occupant of claim 14 in which the inner inflatable member extends across the occupant's lap.

17. The method of restraining an occupant of claim 14 including the step of providing a belt enclosure between the occupant and the remote anchor which belt reciprocates in such enclosure.

18. The method of restraining an occupant of claim 14 in which the inflator is located in the inner inflatable member and in the enclosure.

19. The method of restraining an occupant of claim 14 in which the tubular belt member and the inner inflatable member share the load caused by the decelerating occupant with the belt member carrying a greater load during the first phase of deceleration and prior to the completion inflation of the inner member which carries the greater load after complete inflation.

25

20. The method of claim 14 in which the tubular belt member and the inner inflatable member have relative resistance to further elongation as loaded so that the percent tensile loading by the tubular belt and the percent tensile loading of the inner member up to about one hundred at various phases of loading from initial deceleration to maximum loading.

21. The method of claim 14 in which the tubular belt member and the inner member have relative resistance to further elongation as loaded by deceleration of occupant with the resistance of the torso belt member being less than the

inner belt member resistance upon rupture of the torso belt member.

22. The method of claim 14 in which the tubular belt member includes fabric and the rupturable portion is a fiber in such fabric.

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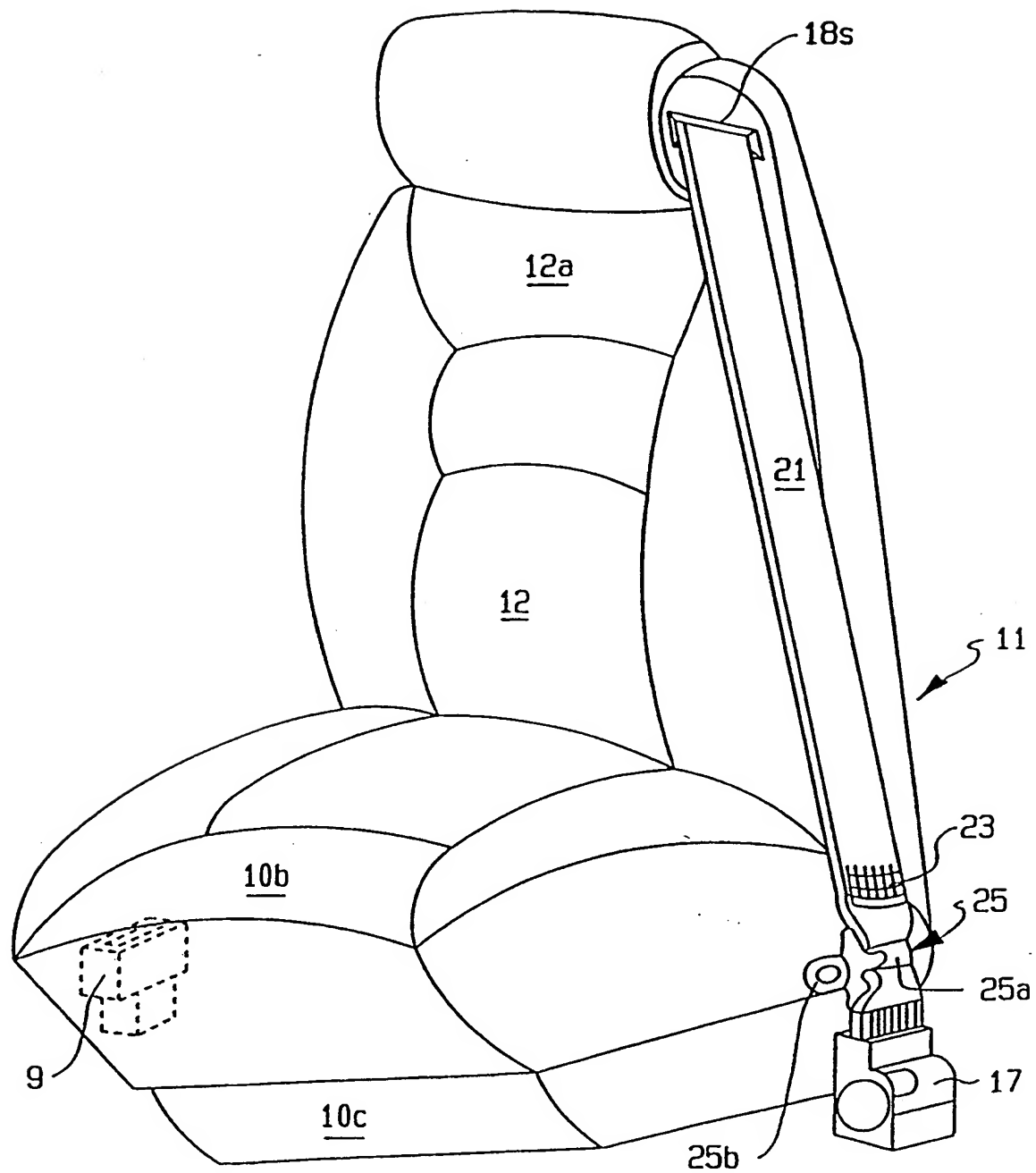


FIG. 1

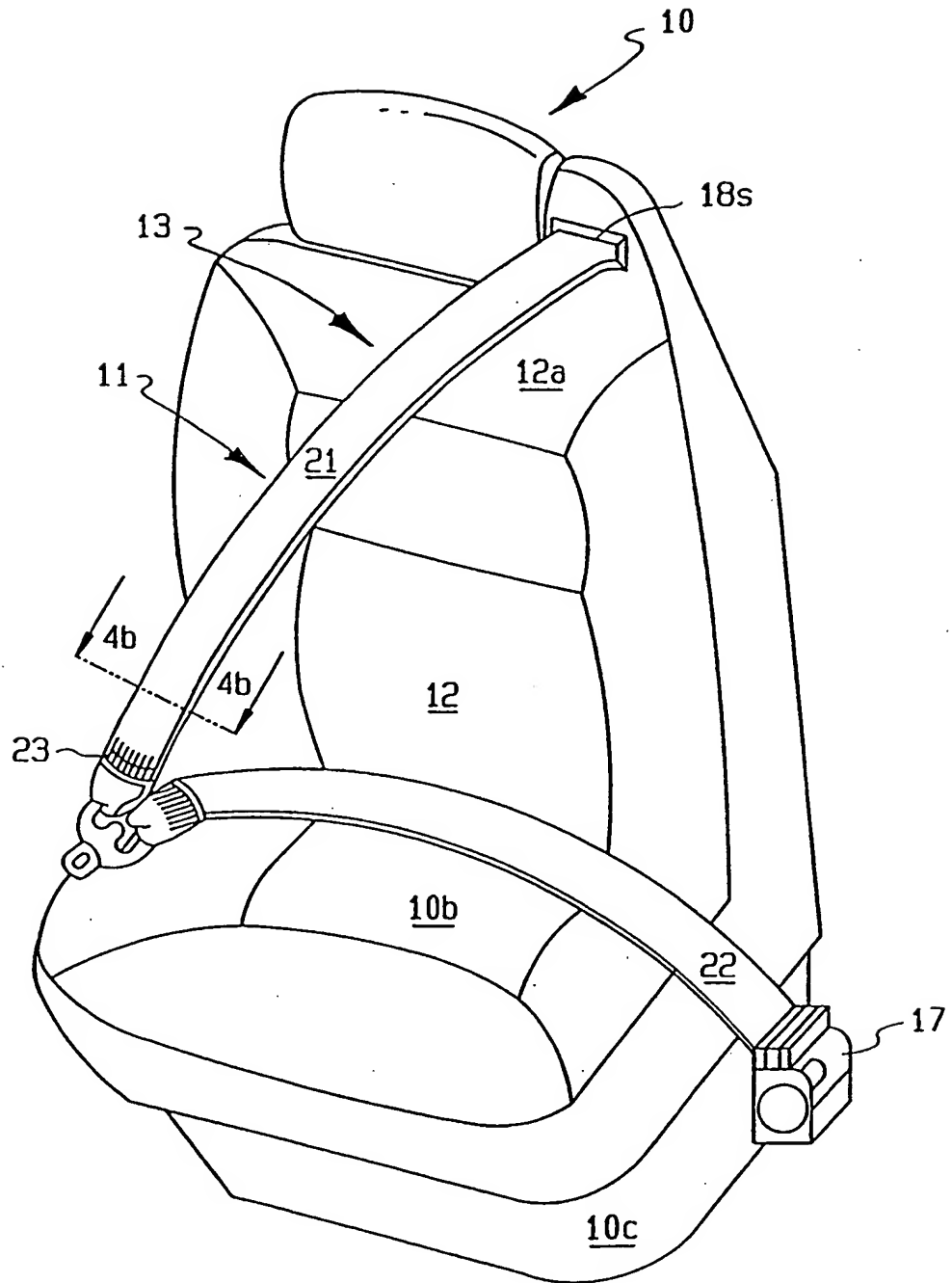


FIG. 2

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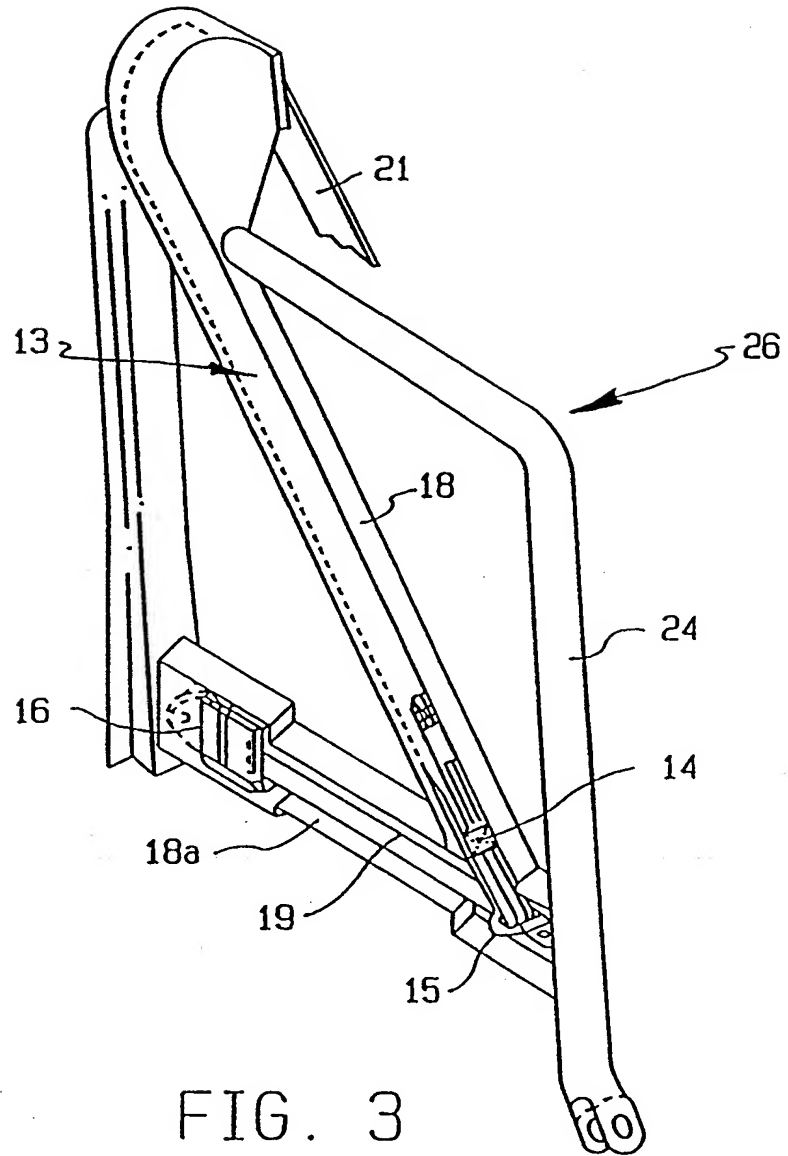


FIG. 3

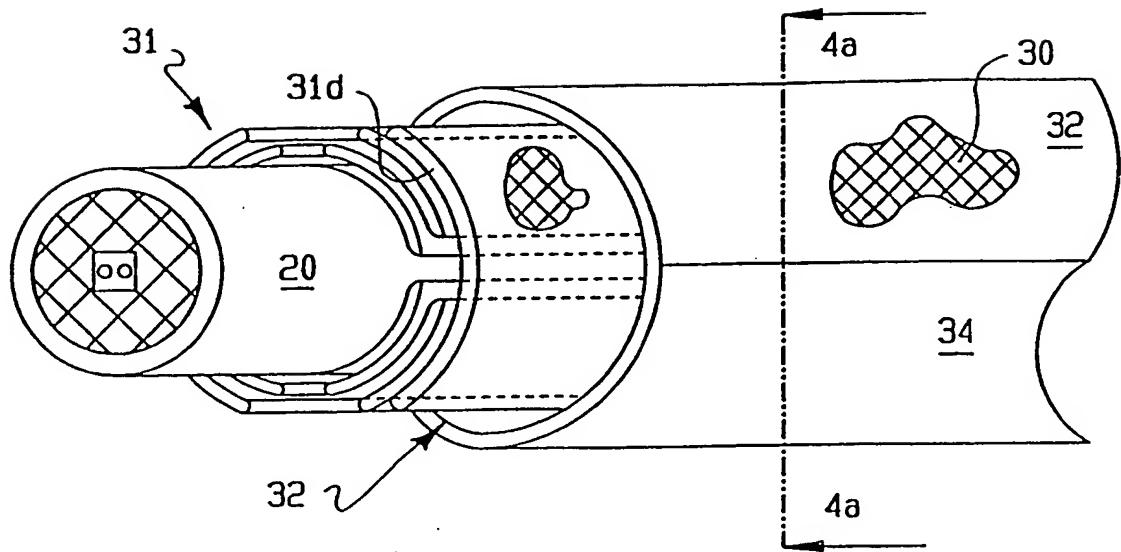


FIG. 4

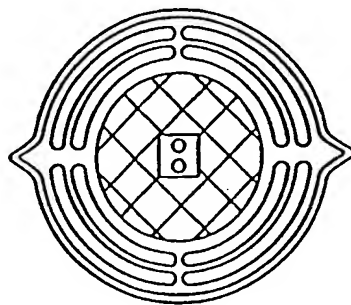


FIG. 4a

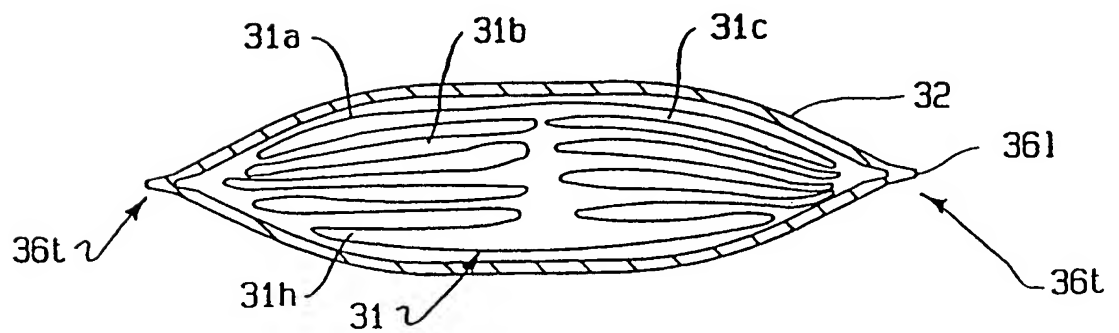


FIG. 4b

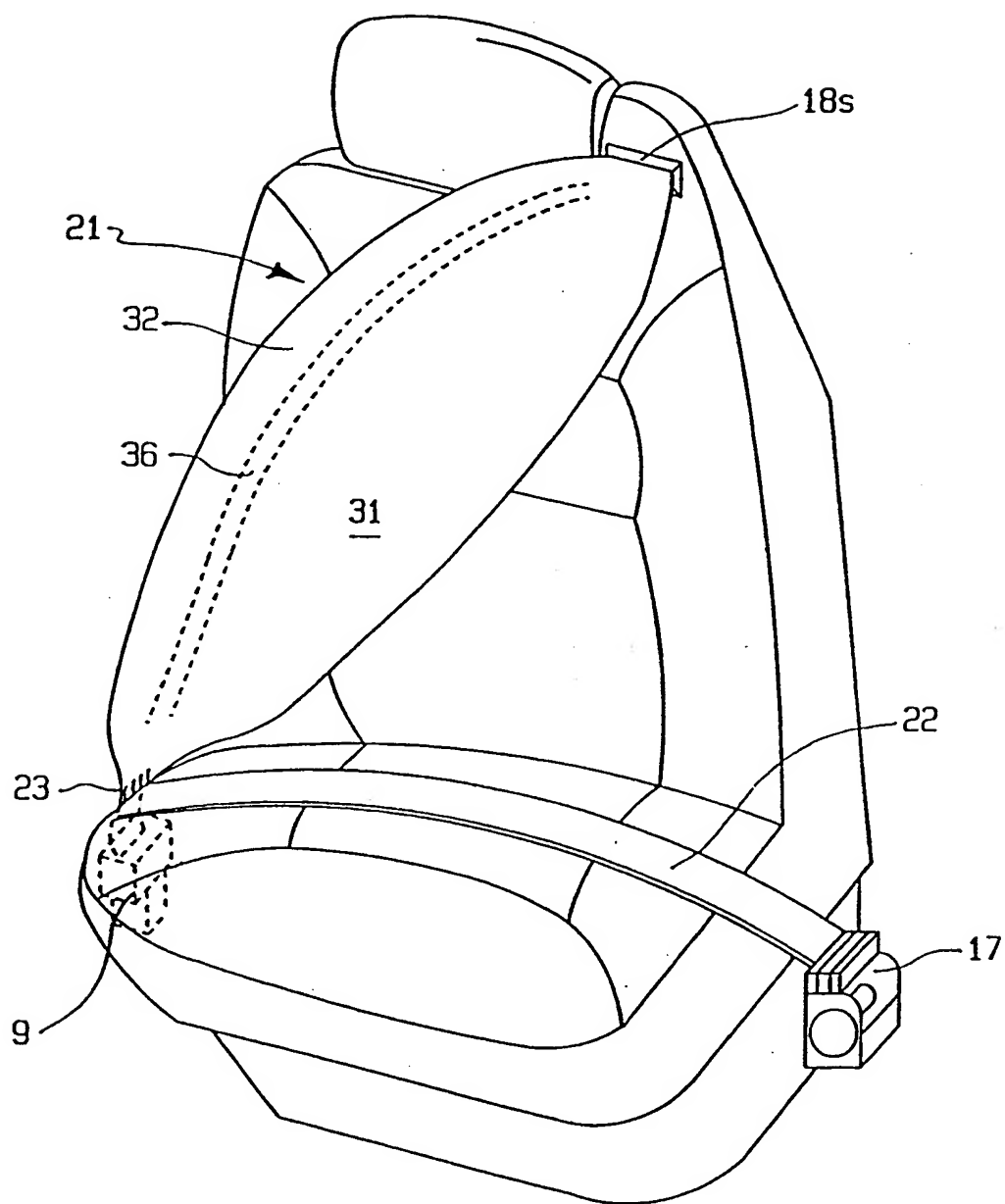


FIG. 5

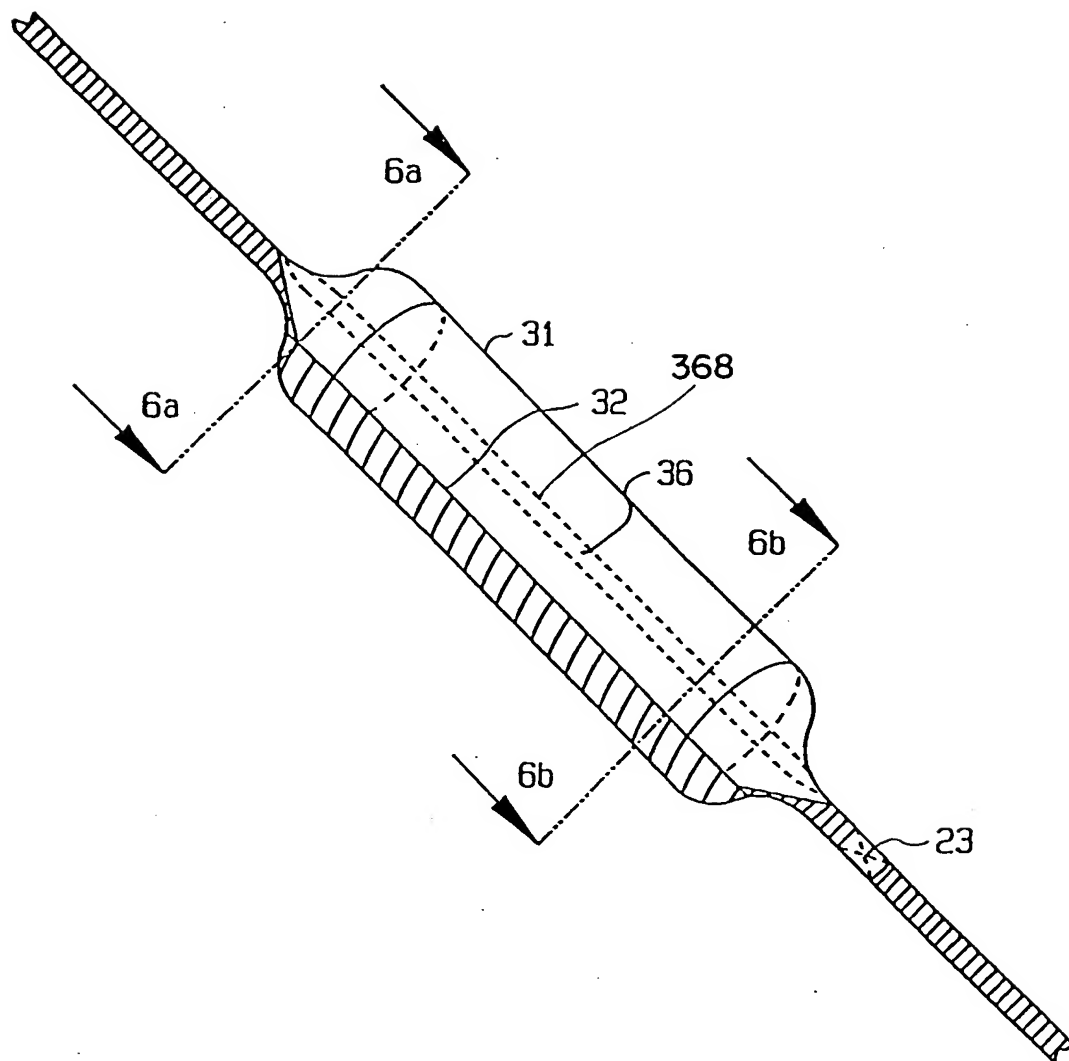


FIG. 6

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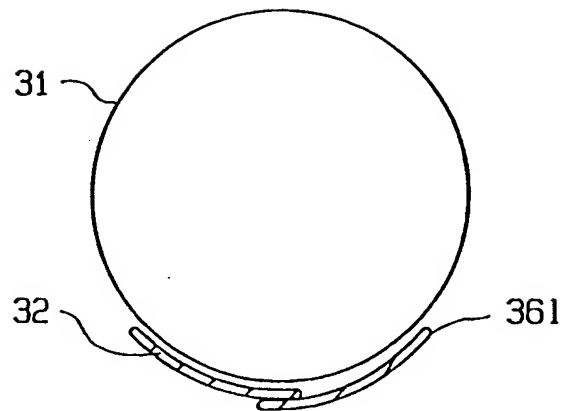


FIG. 6a

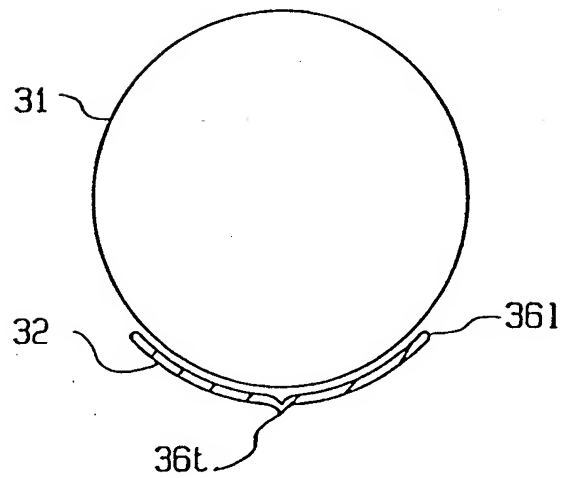


FIG. 6b

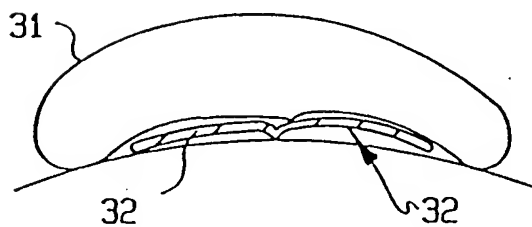


FIG. 6c

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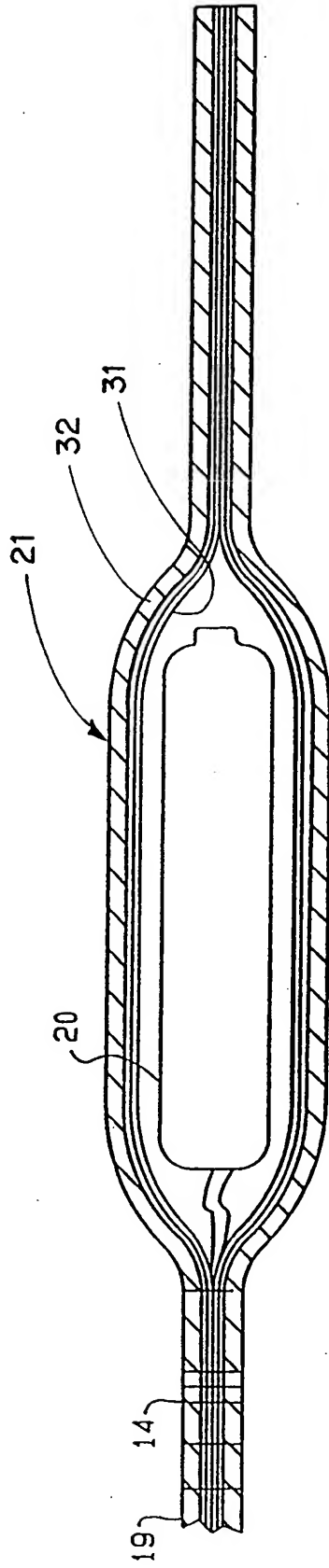


FIG. 7

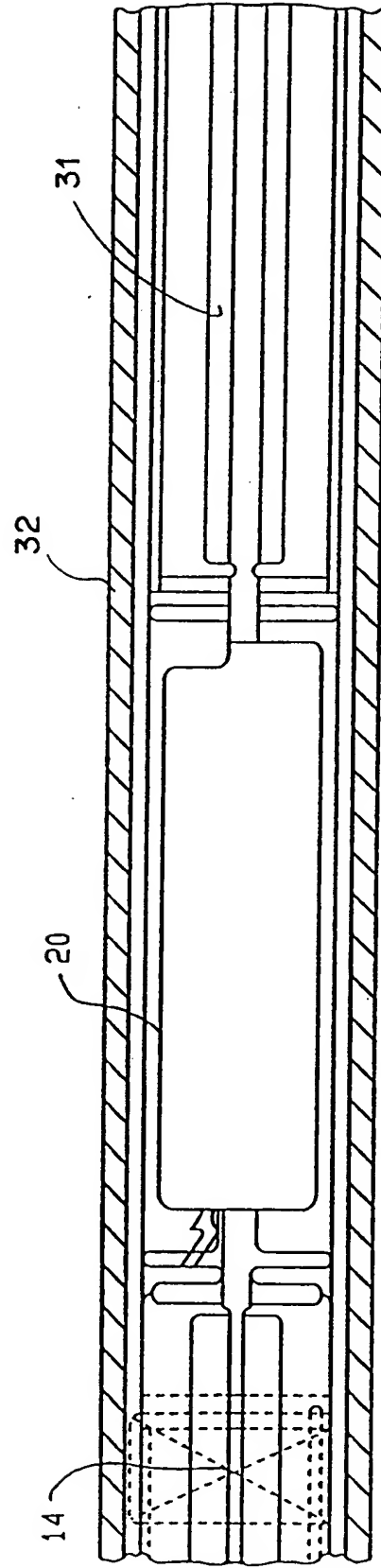


FIG. 8

FIG. 9

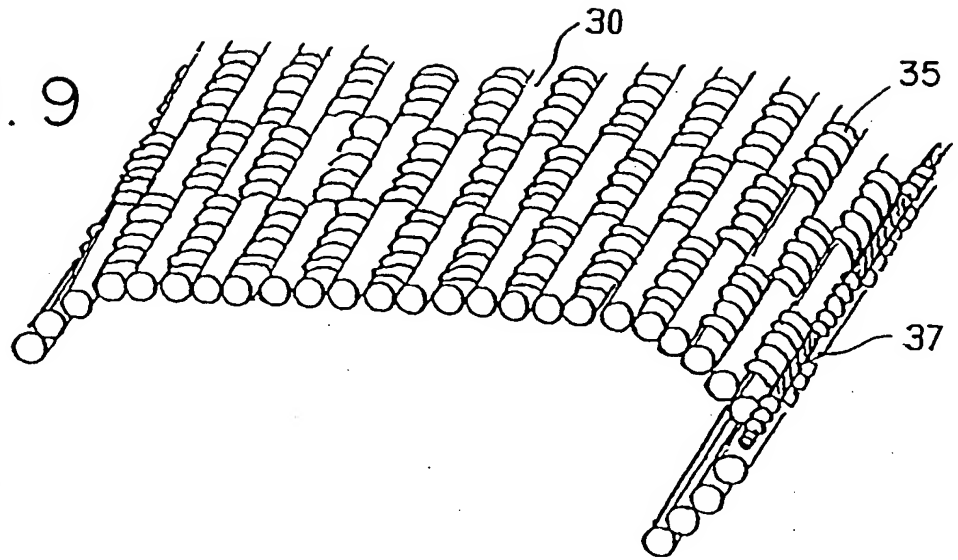
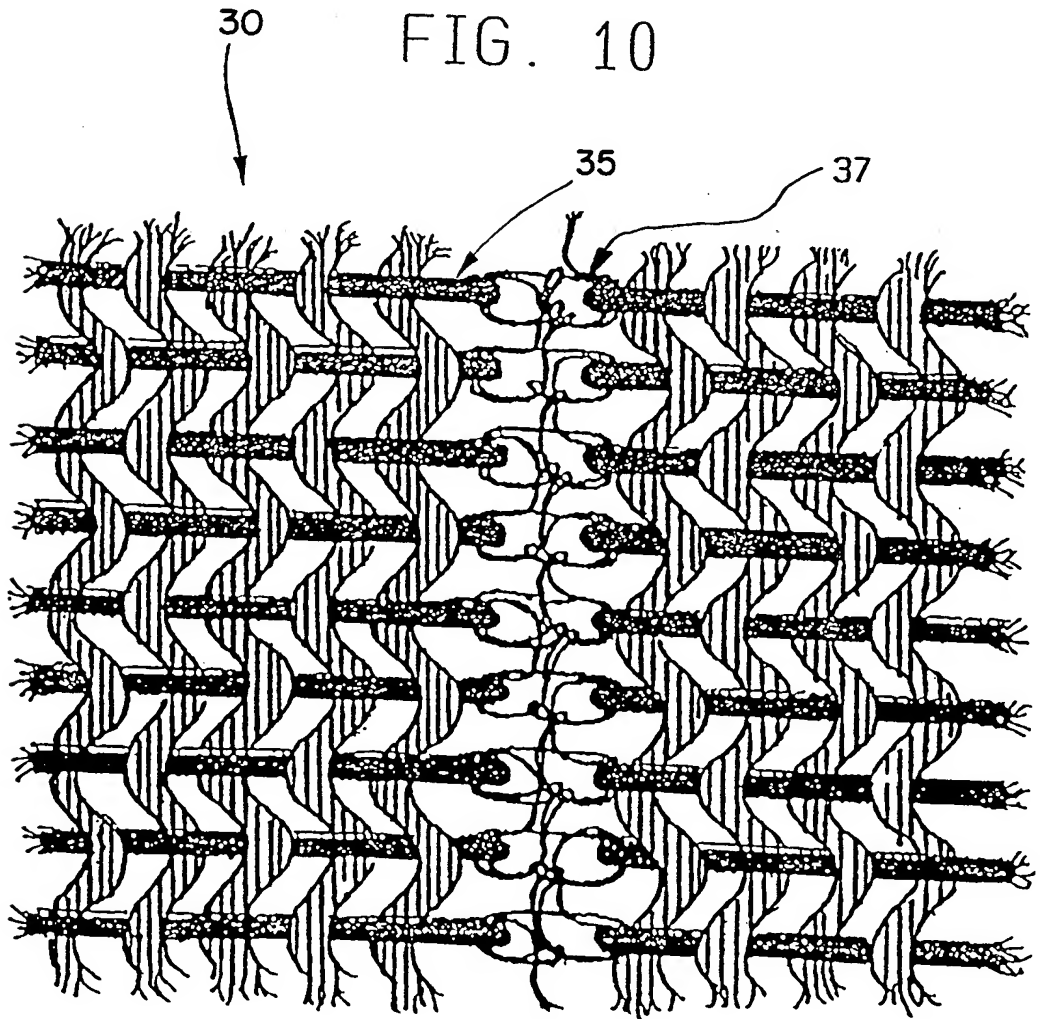


FIG. 10



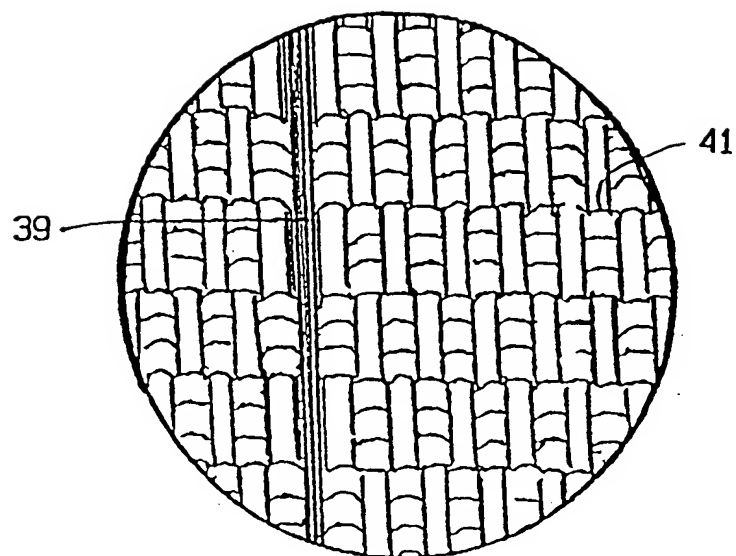


FIG. 11

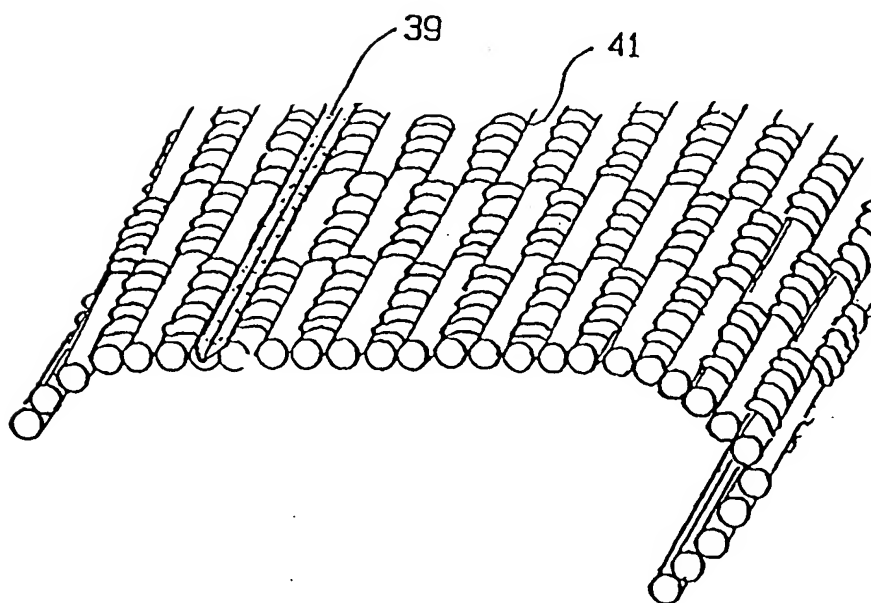


FIG. 12

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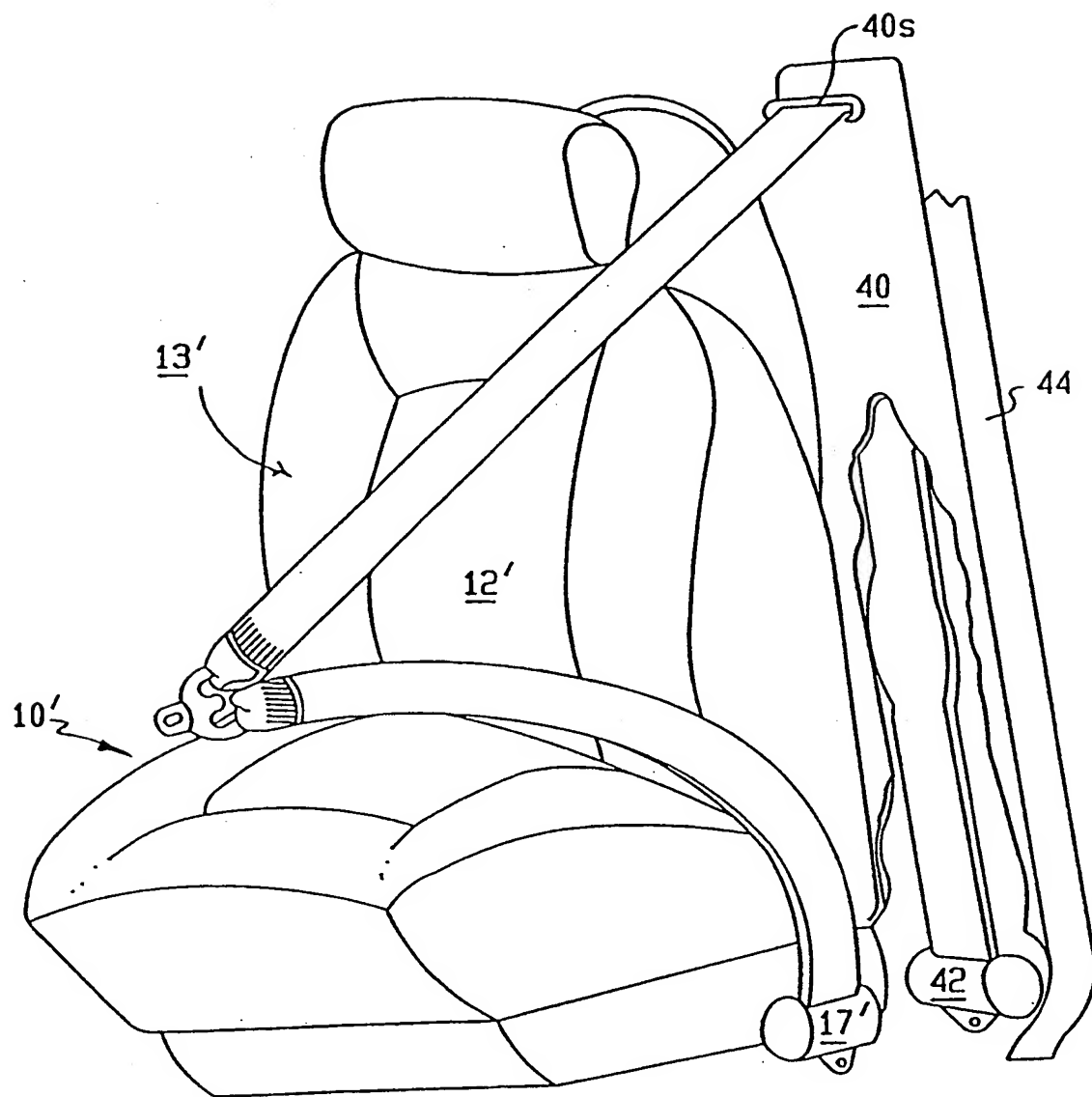


FIG. 13

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/US99/13399

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :B60R 21/18

US CL :280/733, 743.1

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 280/733, 743.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5,383,713A (KAMIYAMA et al.) 24 January 1995, fig. 2.	1-6, 9-16, 18-22
-----		-----
Y		7, 8, 17
Y, P	US 5,851,055 A (LEWIS) 22 December 1998, fig. 2.	7, 8, 17
A, P	US 5,839,753 A (YANIV et al.) 24 November 1998, figs. 1-2.	1-22
A	US 4,348,037 A (LAW et al.) 07 September 1982, fig. 3.	1-22
A	US 4,741,574 A (WEIGHTMAN et al.) 03 May 1988, fig. 5.	1-22

☐ Further documents are listed in the continuation of Box C.
 ☐ See patent family annex.

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*O* document referring to an oral disclosure, use, exhibition or other means	
*P* document published prior to the international filing date but later than the priority date claimed	

Date of the actual completion of the international search

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